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The Impacts of Population Density, and State & National Litter Prevention Programs on Marine Debris

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by

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ABSTRACT

Marine debris is improperly disposed of solid waste, also called litter, which is deposited in the marine environment (NOAA, 2010). Litter prevention techniques such as fines, cleanups, incentives, and others, can help to decrease litter, and ultimately decrease marine debris. This research analyzed 2000 and 2010 International Coastal Cleanup (ICC) data obtained from The Ocean Conservancy to ascertain whether certain litter prevention techniques did reduce amounts and types of marine debris found in coastal areas. The litter prevention techniques analyzed included state bottle bills, voluntary monofilament fishing line recycling programs, and the Keep America Beautiful (KAB) cigarette butt litter prevention campaign. In addition, coastal population density and coastline length were also studied to uncover any potential impact they may have on marine debris amounts.

This study found no significant connection between population density and kilometers of coastline and marine debris amounts. In addition, no statistically significant difference of marine debris amounts was found between states with bottle bills and without bottle bills for 2000 or 2010. Florida has the highest participation in the monofilament line recycling and was analyzed to find any difference between Florida and national averages. No significant difference was found between Florida and the national averages of fishing line debris for the year 2000 or 2010. Finally, there was

no significant reduction in cigarette butt litter from 2000 to 2010 (the KAB cigarette butt litter prevention program began in 2002), but there was an increase in cigarette butts per smoker from 2000 to 2010. Other aspects that could impact marine debris amounts are also discussed to help understand the complex causes that lead to marine debris.

Despite these results, the study did highlight some interesting trends. OR, LA, AL, MS, and NC had the largest decreases in marine debris per capita from 2000 to 2010, with decreases of 87%, 79%, 65%, 54%, and 52% respectively. RI more than doubled the amount of marine debris per capita, up 52%, from 2000 to 2010, and DE increased per capita debris 91% in the same time period. RI and DE also saw large increases in marine debris per kilometer coastline, along with MD, over the ten year time span. In addition to population, bottle bill data also provided some interesting clues to potential marine debris reduction. There was no statistical difference between bottle bill and non-bottle states, but bottle bill states did have slightly lower amounts of returnable debris both years. Similar results were found for monofilament fishing line debris. There was no statically significant difference between Florida and the national average of fishing line debris, but Florida did have 92% less fishing line debris than the national average in 2010. The cigarette butt marine debris data, analyzed to find the number of butts found per smoker, increased from 2000 to 2010, which is the opposite trend that was expected. This is most likely due to increased awareness of the impacts cigarette butt debris can have on the environment which is discussed.

CHAPTER 1: INTRODUCTION & BACKGROUND

This thesis examined the effectiveness of state and national litter prevention and control techniques on reducing types and total amounts of marine debris. The study was undertaken to ascertain how much of an impact, if any, certain types of litter prevention and control programs had on marine debris amounts and types. Because of the impacts of marine debris, outlined in the background information and literature review of this thesis, it is important to understand if litter prevention and control techniques can in fact reduce marine debris amounts.

According to the National Oceanic and Atmospheric Administration (NOAA, 2010), marine debris is solid waste that ends up in rivers, wetlands, coastal areas and beaches, mangrove ecosystems, the open ocean, and any other aquatic environment that is connected to the oceans. Once in the environment, marine debris has a myriad of environmental, economic, and social impacts. But where does this solid waste, which ultimately becomes marine debris, originate from?

According to Porter (1995), and the U.S. Environmental Protection Agency (EPA) (2010), the average American citizen produces approximately 1.814kg (4 pounds) of solid waste per day. That equates to more than 635kg (1,400 U.S. pounds) of garbage per person per year, and a total of approximately 220-227 metric tons (243-251 million U.S. tons) of household

waste produced per year in the U.S. alone. Approximately 30-40% is recycled, but the rest ends up in landfills and incinerators (Louis, G., 2004); the EPA (2010) reports that 33.8% of waste was recycled in 2009. However, all these statistics do not include the waste that is improperly disposed of via littering or illegal dumping because it is extremely difficult to track waste that is improperly disposed (Huffman, K. et al, 1995). Before domestic laws such as the Marine Protection, Research, and Sanctuaries Act of 1972 (16 U.S.C. 1431), and the Shore Protection Act of 1988 (33 U.S.C. 2601); and global laws such as the International Convention for the Prevention of Pollution from Ships (Annex V), and the London Convention (International Maritime Organization, 2011), much of the domestic and global waste was simply brought out to sea on large barges and dumped into the ocean (Marine Debris, EPA, 2010). Once our shorelines began to see the effects of ocean dumping through washed up trash, some of it very hazardous, the U.S. passed laws preventing ocean dumping. This caused a substantial decrease in shoreline trash, especially hazardous and medical wastes. However, marine debris is still a major problem affecting the health of ocean ecosystems, the lives of ocean species, and the lives of people that depend on the ocean for their livelihoods. Where is this debris coming from if it is not being dumped directly into the ocean? The answer is, it's coming from improperly disposed of solid waste on land; in other words, litter.

Litter Background

Litter is a nuisance that has plagued the United States, and many other countries, for decades. Litter, fundamentally, is misplaced solid waste

and has environmental, economical, and social impacts to all communities and ecosystems (Keep America Beautiful, Litter In America, 2010). Litter is an anthropogenic environmental issue and tends to be higher in urban areas where population density is higher (Chapman, C., & Risley, T. 1974). Environmental impacts of litter include dangers to wildlife, the pollution and obstruction of waterways, soil pollution, ecosystem disruptions, and potential human health issues. Economic impacts include the cost of cleanup, negative influence on tourism, and general negative impacts on business if consumers choose to shop elsewhere when an area is littered (Florida Center for Solid and Hazardous Waste Management, 2002). The economic cost of litter, including cleanup and decreased business traffic in littered area, costs the U.S approximately $11.5 billion per year, with businesses paying over $9 billion of that total (Keep America Beautiful, Litter Prevention, 2006).

In addition to environmental and economic impacts, litter has social impacts that include decreased neighborhood pride and cohesiveness, increased crime, and general community decline (Clarke, 1995). Items that are commonly littered include cigarette butts, a myriad of food containers, plastic bags, beverage containers, and much more (NOAA, 2010). Several different approaches have been attempted when trying to control and prevent litter, such as public education, law enforcement, increasing the number of trash/recycling receptacles, curbside recycling, community cleanups, bottle bills, voluntary recycling for specific items, and disposal fees and taxes, but no one approach is perfect (Huffman, K., et al, 1995).

However, some approaches are better than others, and could be more effective if either better enforced or better understood by individuals.

Marine Debris Background

A specific form of litter is marine debris. Marine debris is solid waste that ends up in rivers, wetlands, coastal areas and beaches, mangrove ecosystems, the open ocean, and any other aquatic environment that is connected to the oceans (Information on Marine Debris, 2010). The debris gets to these waterways mainly by flowing with rain-water from land-based sources of litter, through storm water systems (storm water runoff is generally untreated and flows straight to the intended discharge area), to marine environments (Information on Marine Debris, 2010). Marine debris can be extremely detrimental to the marine environment. The debris can impact wildlife through water pollution, waterway obstruction, ingestion, food web bioaccumulation, habitat destruction, and much more (Marine Debris, 2010). Marine debris also has economic and social impacts. Debris can get caught in fishing nets or on fishing lines, can clog discharge pipes, deter beachgoers from visiting a littered beach, necessitate cleanup costs for state and local governments, and pose a human health risk (Trash Travels, 2010). The debris can also disrupt social activities, such as family outings, and public safety (Marine Debris Reports Submitted to Congress, 2008).

According to The National Oceanic and Atmospheric Administration (NOAA), the Environmental Protection Agency (EPA), and The Ocean Conservancy, between 60 and 80% of marine debris originates from land-

based litter sources, and up to 29% of that is from smoking related activities. (Trash Travels, 2010; Information on Marine Debris, 2010) Therefore, the biggest area(s) to target in order to lessen the amounts and impacts of marine debris on the marine environment would be land-based litter sources, including smoking related litter. Land-based sources of litter can be reduced using litter prevention sources mentioned previously (public education, law enforcement, increasing the number of trash/recycling receptacles, curbside recycling, community cleanups, bottle bills, disposal fees and taxes, and other area specific programs).

National & State Scale: Why Not Local?

Often, in geography papers, a local scale is used to study the topic of interest. Local scales, socially, are generally defined as areas where there can be regular face-to-face experiences between residents (Appleton, 2002). The litter prevention techniques analyzed in this thesis, bottle bills, monofilament line recycling, and the KAB cigarette butt litter prevention program, mainly depend on society's response to the implementation of those particular programs. Geographers have often used overtly political scales such as nations, states, cities, etc (Paasi, 2004). This is the approach that this thesis takes in outlining scale boundaries for each litter prevention technique analyzed. The reason that overtly political boundaries were chosen is because bottle bills are implemented at the state government level, monofilament line recycling begins with the state level of Fish and Wildlife (such as Florida Fish and Wildlife Conservation Commission), and the KAB cigarette butt litter prevention program has been implemented nationally. In

addition, the International Coastal Cleanup (ICC), while recorded at the local level, was only available at the state level for this study.

However, even though this thesis uses large scales of study, such as state and national boundaries because laws and techniques are implemented at large scales of study, it is a limitation of this study. Often local conditions, such as law enforcement presence, availability of waste receptacles, volume of river discharge into the marine environment, and much more, can impact marine debris amounts. In addition, ecological processes such as ocean currents and wind patterns, transcend political boundaries, and these processes can also impact marine debris amounts. There is general agreement among geographers, and other scientists, that studies need to move beyond the static definitions of scale, such as state boundaries, and that often time the smaller the scale of study the better (Rangan & Kull, 2009). These arguments are well supported and that is why the scale used in this thesis, while chosen because of the nature of the litter prevention techniques and the nature if the ICC data, is a limitation of this study.

Following this introduction there is a literature review of the pertinent research, a detailed explanation of the research design and study area, and an in depth description of the methods used, all of which supports the importance of this study and explains the analysis used to answer the research questions. In addition there is also a description and analysis of the results found, a conclusion which reviews the research questions and the answers uncovered by the study, and a section on possible future research related to this topic.

CHAPTER 2: LITERATURE REVIEW

The impacts of marine debris are numerous and encompass human health and safety impacts, economic impacts, and environmental impacts. Environmental impacts of marine debris are better understood than the economic and health impacts. Reviewing the literature to understand the impacts is important, because once the impacts are well understood, the importance of studying ways to reduce marine debris can be supported. There is data regarding the types and amounts of marine debris found in the environment including literature by NOAA (2010), The Container Recycling Institute (2010), The Florida Department of Environmental Protection (2002), Florida Center for Solid & Hazardous Waste Management (1998 & 2002), Keep America Beautiful (2010), Novotny, T., & Zhao, F. (1999), and The Ocean Conservancy (2010). In addition, there have been numerous studies on road side litter (Burgess, R., & Clark, N., 1971; Casey, L., & Lloyd, M., 1977; Chapman, C., & Risley, T., 1974; Levitt, L., & Leventhal, G., 1986; Naughton, M., et al, 1990), and there have been numerous programs that attempt to reduce litter such as taxes and fees or curbside recycling. However, these litter prevention/reduction programs' effectiveness at reducing marine debris have never been studied. The literature reviewed is comprised of marine debris impacts and litter prevention techniques with particular emphasis on bottle bills, monofilament fishing line recycling, and

cigarette litter prevention. Also, there is literature that addresses using volunteer collected data, which this thesis does use to ascertain whether litter prevention and control methods do lessen marine debris amounts.

Impacts of Marine Debris

Marine debris can impact human health, the economy, and the environment. While the amount of hazardous waste and debris has decreased since the late 1980s, there are still some items that litter our beaches that are hazardous to human health. These include items such as tampons, needles, and cigarette butts. These items often make it to our beaches and coastal waters from land based sources and can transmit disease and bacterial infections (Tudor, D., & Williams, A., 2003). In addition, items like broken glass can also pose a safety hazard (Marine debris reports submitted to U.S. congress, 2008). Debris can also impact economies, from the local level all the way up to the global level. Debris like ropes can damage vessels and cost owners money for repair, abandoned fishing gear (traps and nets) can continue to catch animals that simply stay caught in the gear, not adding to the coastal economy and not contributing to their ecosystem (Information on Marine Debris, 2010). In addition, debris can transport alien, invasive species from their native waters to other areas where they may drastically reduce local species populations relied upon for livelihoods (Marine Debris, 2010). Also, debris can degrade ecosystems in general, reducing the overall health of the ecosystem and therefore its strength in contributing to the economy. Lastly, of particular importance in Florida and other coastal states, debris can impact tourism, a major

contributor to state and local economies. (Information on marine debris, 2010).

Marine debris can also have a detrimental effect on the environment in general and marine wildlife. Firstly, it is important to realize that most debris is plastic, and can persist in the environment for a very long time (Marine Debris Reports Submitted to Congress, 2008). For example, according to The Ocean Conservancy (2010), plastic bags can persist anywhere from 1-20 years depending on the manufacturer, disposable diapers and plastic bottles for up to 450 years, fishing line up to 600 years, and those are just a few examples. Once debris has made it to the marine environment it can cause entanglement issues for many animals, large and small. Fish can get caught in small plastic six pack rings, fishing line can get wrapped around the flippers and necks of marine mammals, rope can cause major entanglement issues for large mammals such as manatees and whales, and even birds can get caught in fishing line that has snagged on tree branches (Trash Travels, 2010). Once entangled, an animal can suffer minimal impacts such as some difficultly in movement, or more severe impacts such as difficulty feeding, difficulty surfacing to breath, and growth of an animal while entangled can cause circulation problems and loss of limb (Information on Marine Debris, 2010). Ingestion is another major impact of debris on wildlife. Birds are particularly susceptible to ingestion of small plastic pieces that float on the surface, which they ingest when diving for fish. Also, sea turtles often mistake plastic bags for jellyfish and swallow the plastic bag. This can cause impacted intestines and possible death for the turtle (Leous, J, 2005). Both

entanglement and ingestion can lead to the death of the animal. (Trash Travels, 2010)

In addition to wildlife, marine debris can impact marine habitats and ecosystems in general. Debris can get caught on plants, corals, and other structural habitat. This can cause breakage of important species like corals, and can also scour and smother corals and other important structural ecosystems (Marine Debris, 2010). In general, debris can disrupt the food web of the ecosystem, which will ultimately make the ecosystem less stable and less resistant to other negative impacts such as severe weather, oil spills, and invasive species (Information on marine debris, 2010).

Some Litter Prevention Techniques

Decreasing land-based litter is an important step in decreasing marine debris because somewhere between 60 and 80% of marine debris comes from land-based sources, with 29% of that being cigarette butt litter (Trash Travels, 2010). According to The Florida Center for Solid and Hazardous Waste Management (1998), public education is the most effective form of litter prevention and should be a part of any solid waste management plan. This is where teachers, parents, and environmental organizations can step in and education the public about the impacts of litter and proper disposal of waste. Law enforcement also plays a role in litter prevention and control. In the state of Florida for example, law enforcement can give citations to litterers (pedestrians and motorists), starting at $50, and the court may also require community service and add points to the offender's license if applicable (Dept of Environmental Protection, 2002). This can have an

impact on individuals, but the affect is minimal because there is a very small amount of citations given out for littering. This is, most likely, a result of too few officers, and more pressing and/or violent crimes that require their attention. In addition, in most states, as in Florida, the litter citations are grouped together with 'other' miscellaneous crimes for records purposes (Dept of Environmental Protection, 2002). This is problematic when analyzing the impact that law enforcement can have on litter prevention and control, because there is no empirical way to analyze the data because litter citation records cannot be isolated.

Another approach to preventing and controlling land-based litter, and therefore decreasing marine debris, is to increase public access to receptacles, meaning trashcans, recycling containers, and ashtrays (all of which, for best results, would be covered) (Thomas, V., 2003). Increased access to receptacles has been shown to decrease litter in natural areas such as beaches, state parks, walking trails, etc (Florida Center for Solid and Hazardous Waste Management, 2002). However, in more developed or urban areas, more trashcans does not necessarily equate to less litter. According to Burgess (1971), increasing the number of trashcans available in a movie theatre had almost no effect on the amount of trash left in the theatre. Casey (1977) found very similar results when studying the behavior of children in an amusement park. In fact, both Burgess (1971) and Casey (1977) found that incentives (either free park tickets or movie tickets) were the most effective way to reduce litter, both in the theatre and in the park. However, when studying cigarette butt litter, Keep America Beautiful found

that for each additional cigarette butt ashtray, there was a 9% decrease in cigarette butt litter (Keep America Beautiful, Litter in America, 2010). Therefore, while increasing the number of trash/recycling receptacles may not have the intended impact, increasing ashtrays seems to have a positive benefit.

Curbside recycling has increased in the United States from approximately 10% to approximately 33% in the last 30 years (Ackerman, 1991). The increase in recycling has had an impact on waste reduction and also on energy savings. Recycling leads to less extraction of raw materials to make products, and also requires less energy than making a container from a raw material (Florida Center for Solid and Hazardous Waste, 2002). However, the effectiveness of curbside recycling on litter is negligible. This is mainly because there is no incentive for recycling in many states, including Florida (Florida Center for Solid and Hazardous Waste, 1998). Some people will recycle because they think it's the right thing to do, but many people choose to litter rather than bring a container home to recycle, because littering is much more convenient and recycling holds no incentive.

To help reduce litter in the environment, publicly funded and volunteer cleanups can be very effective. Either prisoners or road maintenance crews can complete publicly funded cleanups. There is not much research on prisoner-assisted cleanups, but the amount of money and manpower spent by road maintenance crews has been calculated. In 1993, roadside litter maintenance cost the United States over $131 million, and that number has likely increased over time (Florida Center for Solid and Hazardous Waste

Management, 1998). The collection and disposal of litter necessitates the use of road maintenance employees, diverting them from other important road maintenance activities. State transportation agencies nationwide spend approximately 3% of their road maintenance budgets on roadside litter (Florida Center for Solid and Hazardous Waste Management, 1998). This is money and manpower that could be used for other road maintenance and transportation activities, such as filling potholes, fixing street signs and lights, and other crucial transportation related repairs. Volunteer cleanups are very effective, and costs are minimal (just money for supplies). For example, from March to May of 2010, the Great American Cleanup mobilized almost 4 million volunteers nationwide that helped to remove 34,473 metric tons (76 million U.S. pounds) of litter from the environment (Keep America Beautiful, Great American Cleanup Results, 2010), and in 2009 The Ocean Conservancy's International Coastal Cleanup mobilized almost half a million volunteers who removed over 3,175 metric tons (7 million U.S. pounds) of marine debris in 108 countries (Trash Travels, 2010), and those are just two of many examples. However, although these cleanups are very effective and much needed, this method seems inefficient when addressing the big picture, since it is addressing the issue of litter after the fact. If litter was prevented rather than cleaned up, this would be a much more efficient way of addressing the problem, with the potential saving of money and time.

Bottle Bills

Bottle bills and disposal taxes and fees are designed to prevent, rather than control, litter. Bottle bills are state laws passed to encourage

consumers to return beverage bottles to be recycled. A deposit fee is charged to the consumer at the time of purchase (usually five cents per bottle), and when the consumer returns the bottle, they receive a refund of the deposit fee (Container Recycling Institute, 2010). States that have bottle bills include California, Vermont, Massachusetts, Rhode Island, Oregon, Iowa, New York, Connecticut, Maine, and Delaware. The New York bottle bill, and its impact on roadside litter, was studied at the time the bill was passed. Levitt (1986) tested the effectiveness of the bill by measuring roadside litter at two sites in New York and New Jersey (NJ was the control state because it had no bottle bill) for several weeks prior to and after the bill passing, and also ten and twelve months after the bill passed. Levitt (1986) found that there was a significant reduction in litter at both roadside locations in NY after the bill was passed and when compared to NJ. More specifically, Levitt found that one-year after the bill was passed there was a 56% decrease in returnable litter in NY, and no decrease in non-returnable litter. If they counted only containers with the bill stamp (meaning the containers would have been littered after the bill passed), the decrease in returnable litter was 97%. There can be a cost to consumers associated with bottle bills, including the inconvenience cost of returning bottles and the cost of driving to the return location (Naughton, M., et al, 1990). However, many grocery and retail stores have return machines or service stations so returns can be made while already making a trip to a grocery store (Container Recycling Institute, 2010).

Disposal taxes and fees related to solid waste management have been in place in many areas for 50 years or more, and typically pay for the process of waste management (hauling, incinerating, burying in a landfill, etc.). Dobbs (1991) states, "a user charge for rubbish collection has often been suggested as a means of internalizing the waste management externality." (Pg 221) In his work on the assessment of user charges, he suggests that the externalities of waste management (litter and proper disposal) should be viewed as part of a wider problem, and that in fact proper disposal should have a negative charge (a refund). His suggestion is essentially an incentive based program that rewards proper disposal.

Monofilament Fishing Line

The voluntary monofilament fishing line recycling program is a litter prevention method that specifically targets recreational fishermen. The program's goal is to educate fishermen about the impacts of improperly disposed of fishing line, encouraging them to deposit any used line in special bins placed on piers and other fishing locations (Figure 1) (Florida Fish and Wildlife Conservation Commission, 2009). This program is completely voluntary, and was first implemented in Florida in 1999. After Florida's success, 25 states have implemented similar programs, but none are as widespread or successful as Florida's program. In the entire state of FL, 46 out of the 67 counties participate in the program with 1061 special bins placed (indoor and outdoor) at popular fishing locations throughout the state, such as the North and South Skyway fishing piers, Tierra Verde pier, and many more (Florida Fish and Wildlife Conservation Commission, 2009).

Volunteers walk the piers educating the public, emptying the bins, cleaning the line, and sending it to Berkley Fishing for recycling. The education of the fishermen is crucial because if improperly disposed of, fishing line can persist in the marine environment for up to 600 years (Trash Travels, 2010). In addition, of particular concern to wildlife, fishing line is essentially invisible. This means it can easily become an entanglement or ingestion issue, causing serious harm to marine wildlife (Marine Debris, 2010). In addition to public education, the program is also a recycling program and the recycled line is used to make fish habitat (Florida Fish and Wildlife Conservation Commission, 2009).

Figure 1: Fishing Line Bin

Cigarette Butts

Cigarette butt litter has been the number one littered item found during the International Coastal Cleanup (ICC) since the first ICC in 1985 (The Ocean Conservancy, 2010), and according the Keep America Beautiful (Litter in America, 2010) is the number one item littered in America. In addition to cigarette butts, there is other waste associated with smoking including cardboard packs and cartons, and plastic wrapping (Novotny, T., & Zhao, F., 1999). In 2002, Keep America Beautiful implemented their

Cigarette Butt Liter Prevention Program, which is part public education and part teamwork with local governments to increase receptacles. Since its implementation, the program has helped communities in every single state in the U.S., from downtown urban areas, to parks and beaches, to suburban roadside communities, to college campuses, carry out a public education and outreach plan to lessen the amount of cigarette butt litter. The plan includes educating smokers, handing out pocket ashtrays, surveying smokers to determine littering behavior, and follow up research to ensure the success of litter prevention is ongoing (Keep America Beautiful, 2009).

As types of litter prevention techniques, bottle bills, monofilament programs, and cigarette butt litter programs, are all a combination of incentive based, public education, and volunteer programs. Additionally, in the case of cigarette butt litter prevention, the program also includes increased receptacle availability. All of these techniques are aimed at preventing land-based litter from entering the environment. Since 60-80% of marine debris comes from land-based sources, the techniques could also help prevent marine debris. An important thing to note from all of the literature reviewed above is that land-based litter prevention and control techniques, such as bottle bills, monofilament line recycling, and cigarette butt litter prevention campaigns, have not been empirically analyzed with regards to their effectiveness on reducing marine debris.

Using Volunteer Collected Data

The use of volunteers, or non-specialists, to collect data has been employed for centuries (Bois, S., et al 2011). It has long been recognized

that compiling data collected from multiple sources, including professionals and amateurs, could lead to gathering much more information than by using one researcher alone (Kennedy, 1992). The use of volunteers has become a primary method for large scale data collection such as The Invasive Plant Atlas of New England, and today is most recognized in the field of ornithology (Bois, S., et all, 2011). The accuracy of volunteer collected data has been questioned, but multiple studies have found that with some training volunteers are able to accurately collect data on complex subjects such as terrestrial vertebrates (Lovell, et al, 2009), invasive crab identification (Delaney, et al, 2008), and more. If volunteers, with some training, are able to collect data on these complex subjects, tracking types and amounts of marine debris is relatively easy by comparison. The data collection involved in The International Coastal Cleanup is comprised of tracking debris types and amounts by tallying up the debris as the volunteer participates in the cleanup process (Figure 2). The total debris types and amounts are calculated by the site captain for each site and then submitted to The Ocean Conservancy to analyze on a state, national, and international level. The cleanup has been ongoing for 26 years, with the data card changing slightly each year. The data card makes it relatively easy for volunteers to track debris data, and the ICC has the ability to collect global marine debris data that would not be possible without the use of volunteers.

Figure 2: ICC Data Form

In conclusion, the impacts of marine debris are numerous and include health and safety impacts, economic impacts, and environmental impacts. It is important to understand these impacts in order to justify the reasons for studying techniques that may lessen the amounts and types of marine debris. There are some litter prevention techniques, most notably bottle bills, monofilament line recycling, and cigarette butt litter prevention programs, that aim to reduce the amount of litter in the environment that have not been studied to determine their effectiveness at reducing the amount of marine debris. Using volunteer collected data has been shown to be effective when volunteers are educated about the data collection process, and in the case of marine debris can be used to determine litter prevention technique's effectiveness on reducing marine debris.

CHAPTER 3: RESEARCH DESIGN

State & National Techniques Analyzed by This Project

There are different environmental regulations and/or public outreach programs aimed at preventing or reducing litter, and these regulations or programs can be undertaken at the local, state, national, and/or international level. Some examples include international treaties such as the United Nation's Convention on the Law of the Seas, national laws such as the U.S. EPA's Ocean Dumping Act of 1988, state laws such as Bottle Bills, and local/state/national public education programs undertaken by nonprofits such as The Ocean Conservancy or Keep America Beautiful. Each technique may help to prevent and control litter and marine debris, thereby lessening the amounts of debris that enter the environment. It is important to understand what impacts, if any, litter prevention programs can have on marine debris because lessening the amount of marine debris in the environment would lessen the impacts of that debris.

Marine debris data was obtained from The Ocean Conservancy's Annual International Coastal Cleanups (ICC) for all U.S. states for the year 2000, and also for the year 2010 (Mallos, 2010). The 2000 ICC data, in the form of an excel file, was provided by Nicholas Mallos, the head of the Trash Free Seas program facilitated by The Ocean Conservancy (Mallos, 2010). The 2010 ICC data was obtained in the form of a PDF from The Ocean Conservancy Website (The Ocean Conservancy, 2011). The Ocean Conservancy has done no extensive analysis on this data other than monitoring trends of all locations over time. The data will be analyzed to see

if there is a correlation between coastal population density and debris amounts, Bottle Bill status and debris amounts, Monofilament line recycling programs and debris amounts, and the effect of the Keep America Beautiful cigarette litter prevention program on total U.S. cigarette butt debris.

As part of the research design, selecting the study area for each section of analysis is important to help understand any trends in the data. Bottle bill states selected were all coastal states that have a current bottle bill. The non-bottle bill states were selected because they are somewhat similar in size and location to a bottle bill state, but more importantly because there has either been a failed attempt to pass a bottle bill in the past and/or there has been other political activity such as proposed bills to help address roadside litter, increase recycling rates, or create jobs (Container Recycling Institute, 2010).

While there are other states who have participated in the voluntary monofilament line recycling program, ranging from Texas with 12 counties and 64 bins to Alabama with only 2 bins, no one state has higher or longer participation than Florida (Florida Fish and Wildlife Conservation Commission, 2009), and that is why it is selected as a focus for this program's effectiveness on reducing a specific type of marine debris.

The cigarette butt litter reduction campaign, introduced by Keep America Beautiful in 2002, has been implemented in at least one, but in most cases many, communities in every single state in the U.S. (Keep America

Beautiful, 2002). Because of this, the entire nation will be analyzed with regards to cigarette butt litter data and trends.

Problem Statement

Because of the environmental, social, and economic effects of marine debris, it is important to know what impacts various local/state and national litter prevention techniques have on the total amounts of, and certain types of, marine debris in the environment. The goal of this study is to determine if, and how much, these techniques can lessen the amounts, and therefore the impacts, of marine debris.

RESEARCH QUESTIONS

Background

Marine debris is improperly disposed of solid waste, 60-80% of which originates from land-based litter, which ultimately ends up in the marine environment (Marine Debris, EPA, 2010). The three litter prevention techniques that this project will focus on include state mandated bottle bills, volunteer monofilament line recycling programs, and the Keep America Beautiful national cigarette butt litter prevention program which began in 2002 and steadily increased in participation over time. These three approaches to litter prevention will be analyzed with regard to their effectiveness on reducing the amounts and types of marine debris, therefore lessening the impacts of marine debris. In addition, because litter and marine debris are caused by humankind, the impacts of coastal population

density on marine debris will also be investigated. Furthermore, the correlation, if any, between length of coastline and marine debris amounts will be studied.

The land along the U.S. coast accounts for only 17% of the nation's land area but is home to more than half of the population of the U.S. (Population Trends Along the Coastal United States, 2005). For this reason, this thesis studied the impacts of coastal population on marine debris amounts. Additionally, bottle bills were chosen because the literature supports a drastic reduction in returnable (beverage containers that can be redeemed for a refund, usually five cents, of a deposit charged when the beverage was purchased) road side litter in states that implemented bottle bills (Levett, L., 1986). Since most marine debris stems from land-based sources there is the possibility that bottle bills could also drastically reduce the amount of returnable marine debris. The monofilament fishing line recycling program was chosen because fishing line has the most detrimental impacts to wildlife, including entanglement, ingestion, and death, (Trash Travels, 2010) and finding a way to reduce the amount of line in the environment is important. The cigarette butt litter prevention program was chosen because cigarette butts are the most littered item and can clog water ways, do not biodegrade, and when ingested can be very toxic to wildlife (Keep America Beautiful, Key Findings, 2010).

Population Research Questions

Does population density along the coast influence marine debris amounts? Does a higher population density lead to higher amounts of marine debris?

The Bottle Bill Research Questions

Does the implementation of a Bottle Bill lessen the amount of returnable marine debris? Does it impact the total amount of marine debris found in the respective state?

Monofilament Line Recycling Program Research Questions

Does the participation of the state of Florida in a volunteer monofilament line recycling program lessen the amount of fishing line debris?

KAB Cigarette Butt Program Research Questions

Does the implementation of the cigarette butt litter prevention program by Keep America Beautiful lessen the amount of cigarette butts found during the International Coastal Cleanup (ICC)? As participation increased over time, did cigarette butt litter decrease?

CHAPTER 4: STUDY AREA

The study area for each section of this research project (population, bottle bill status, monofilament line recycling, and cigarette butt litter) is slightly different depending on the section, data available, and data analysis used. Below is a brief description of each section's study area and why that area is selected.

Population Study Area

The study area for analyzing the International Coastal Cleanup (ICC) data with respect to population density will include all coastal counties of the U.S. The reason coastal counties were selected is because this study is interested in determining if coastal population and kilometers of coastline have an impact on debris amounts found within a particular state. The years 2000 and 2010 are used because that is when a U.S. census was performed, and the U.S. Census provides population density data (United States Census Bureau, 2010; United States Census Bureau 2000).

The Bottle Bill Study Area

Table 1: Bottle Bill and Non-Bottle Bill States

Bottle Bill States	Non-Bottle Bill States
California	Florida
Delaware	North Carolina
Massachusetts	South Carolina
Rhode Island	Texas
Oregon	New Jersey
New York	Maryland
Connecticut	Washington
Maine	Georgia (2000 only)

Monofilament Line Recycling Study Area

Florida is the biggest participator in the voluntary monofilament line recycling program, with 46 of its 67 counties participating and over 1000 line recycling bins (Florida Fish and Wildlife Conservation Commission, 2009). Therefore, Florida's International Coastal Cleanup (ICC) data will be analyzed and compared to the national average for fishing line debris, per capita fishing line, and total marine debris amounts.

KAB's Cigarette Butt Program Study Area

The study area for this data analysis will be the entire U.S., and total cigarette butt litter for the entire nation will be analyzed from the years 2000 (before the program implementation) and 2010 (8 years after

implementation) to see if the program is effective at reducing total cigarette butts litter found during the ICC in the U.S.

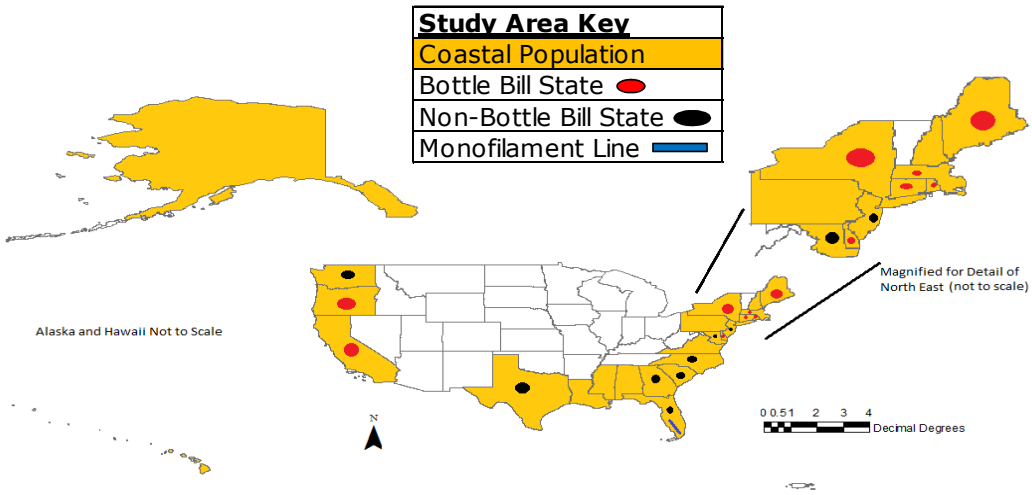

Figure 3: Map of Study Area for Entire Thesis

CHAPTER 5: METHODS

International Coastal Cleanup Data

The International Coastal Cleanup (ICC) data for the year 2000 was obtained from Nicholas Mallos of The Ocean Conservancy. He provided the raw data for marine debris for all states that participated in the 2000 ICC in an excel spreadsheet (Appendix A, pg. 66). The ICC raw data for the 2010 ICC was downloaded as a PDF from The Ocean Conservancy website and input into Microsoft excel for analysis (Appendix B, pg. 70). Once all the data for both years was in excel the program was used to do all calculations, such as averages, per capita amounts, per kilometer amounts, student's t-tests, and all other calculations. Excel was also used to produce all tables and figures presented in this thesis. For each litter prevention technique analyzed in this thesis nonprobability sampling was used because the selection of certain states or the entire United States was not random (Trochim, W., 2006). More specifically, a purposive sampling technique was used because predefined groups were being sought out to ascertain whether a difference in marine debris amounts and/or types could be caused by the implementation of a certain litter prevention technique (Trochim, W., 2006).

Once the raw data was in excel, each study area analyzed for both 2000 and 2010 was isolated into another spreadsheet to begin the analysis of the data. This entailed isolating beverage container debris data,

monofilament fishing line debris data, and cigarette butt debris data, each into a separate spreadsheet to perform all calculations and make tables and graphs to visualize data trends. Excel formulas were used to calculate marine debris per capita and per kilometer coastline for the population analysis, returnable debris per capita and per kilometer coastline for the bottle bill analysis, fishing line debris per capita for the monofilament fishing line analysis, and cigarette butts per smoker for the cigarette butt debris analysis. In addition, the excel function for a t-test was used to calculate the student's t-test for each data set to determine if there was a significant difference in the categories of interest. Below is further detail of the methods used for each subsection of this thesis.

Population Methods

Population density impacts were determined, using U.S. Census data from 2000 and 2010 (United States Census Bureau, 2010; United States Census Bureau 2000), by using Microsoft excel to calculate the amount of marine debris per capita and marine debris per kilometer of coastline. This helped determine if increased population density leads to increased marine debris amounts found during the International Coastal Cleanups (ICC), and, if kilometers of coastline have any correlation to debris amounts. ArcGIS, a mapping program used to geographically represent and analyze data, is used to map per capita debris amounts and per kilometer debris amounts for both 2000 and 2010. A base map of the United States was obtained from Geo.Data.Gov (2011), and once that layer was added in ArcGIS, the editing tool was used to add addition data to the attribute table of the base map.

Marine debris per capita and marine debris per kilometer were each added as a new column of data to the attribute table of the base map so that the data could then be visually displayed on the map. The main purpose of using GIS in this thesis is to examine the data and visualize any potential geographical trends, for example if the north eastern U.S. had very high amounts or the Gulf of Mexico had very low amounts of marine debris per capita.

The Bottle Bill Methods

Total amounts of returnable debris (beverage containers that can be redeemed for a refund of the deposit paid at the time of purchase), per capita returnable debris, and total amounts of all marine debris were compared between bottle bill and non-bottle bill states. All of the calculations will be shown in table form to illustrate any trends in the data. Then averages of beverage containers per capita and per kilometer coastline for bottle bill and non-bottle bill states were calculated. Then a student's t-test is calculated to analyze whether the averages of per capita and per kilometer beverage container amounts are significantly different between bottle bill and non-bottle bill states for both 2000 and 2010.

Monofilament Line Recycling Methods

Total amounts of fishing line debris, per capita fishing line debris, and total amounts of all marine debris were compared between Florida, a state participating heavily in the voluntary line recycling program, and the national averages of those data specifics. The number of fishing line recycling bins used in Florida (and other states) is provided by the Florida Fish and Wildlife

Conservation Commission (Florida Fish and Wildlife Conservation Commission, 2009). All calculations are shown in table form to illustrate trends in the data. A student's t-test is used to analyze whether Florida's total fishing line debris is significantly different than national averages.

Cigarette Butt Program Methods

Since 2002, Keep America Beautiful has worked with communities in all 50 states to help reduce cigarette butt litter. A comparison is done of cigarette butt litter totals found in the 2000 and 2010 ICC for the entire nation. Cigarette butts found per smoker (adult smoking data is provided by the Center for Disease Control for years 2000 and 2010(Center for Disease Control and Prevention, 2010)) is calculated to ensure any reduction in litter found is not due to a reduction in the total number of smokers.

The national cigarette butt litter data for the years 2000 and 2010 were plotted on an excel graph to show any trends in the data. The national statistics on American smokers, from the Center for Disease Control (Center for Disease Control and Prevention, 2010), was also plotted on a graph to determine whether a national reduction in the number of smokers is correlated to any changes in national cigarette butt marine debris amounts. In addition, a student's t-test was performed to determine if there is a significant difference in marine debris amounts of cigarette butt litter between 2000 and 2010, 2000 being two years before the KAB program was implemented, and 2010 being eight years after implementation.

CHAPTER 6: RESULTS & DISCUSSION

Following are the results and discussion for population density, length of coastline, bottle bill status, monofilament line recycling, and the KAB cigarette butt litter prevention program, and how each section impacts marine debris amounts. The data for each section is presented either in table or graph format, or both formats if appropriate. In addition, for the population and length of coastline data, results are presented in maps for both 2000 and 2010.

Population Results

Tables two and three show marine debris data, population data, and length of coastline data from the years 2000 (table 2) and 2010 (table 3). The data included marine debris per capita and per kilometer coastline calculations for both years. Both tables are organized from lowest number of pieces of marine debris per kilometer coastline at the top, to highest number of pieces of marine debris per kilometer coastline at the bottom of the rows. Some of the data presented in the tables is also presented graphically in figures four and five.

Table 2: Marine Debris and Population Data, 2000

State	Total Marine Debris	Coastal Population	KM of Coastline	Population Density (per Sq Km)	Marine Debris Per Capita	Marine Debris per Km
Alaska	20262	526205	10686.04416	49.24226328	0.0385059055	1.896117936
Georgia	7546	915957	160.9344	5691.492931	0.0082383780	46.88867017
Delaware	2277	783600	45.061632	17389.51665	0.0029058193	50.53079303
Pennsylvania	15255	6030582	143.231616	42103.70705	0.0025296066	106.5058150
Washington	29444	4587173	252.667008	18155.01373	0.0064187682	116.5328241
Oregon	67544	1807961	476.365824	3795.320548	0.0373592129	141.7901885
Connecticut	20362	3405565	128.74752	26451.4998	0.0059790373	158.1545027
Louisiana	107195	3534969	638.909568	5532.815874	0.0303241697	167.7780477
Hawaii	203708	1211537	1207.008	1003.752254	0.1681401393	168.7710438
Maine	65967	1183750	366.930432	3226.088372	0.0557271383	179.7806730
S Carolina	57386	1653346	300.947328	5493.805215	0.0347090083	190.6845307
Virginia	55087	4793666	180.246528	26595.05319	0.0114916225	305.6203113
N Carolina	161076	2003669	484.412544	4136.286363	0.0803905236	332.5182264
Florida	772595	15655053	2172.6144	7205.62885	0.0493511584	355.6061306
Texas	219953	6849874	590.629248	11597.58685	0.0321105177	372.4045173
Maryland	20692	4864510	49.889664	97505.36704	0.0042536658	414.7552487
Massachusetts	133719	6125311	308.994048	19823.39479	0.0218305650	432.7559086
New Jersey	115874	8311913	209.21472	39729.10224	0.0139407138	553.8520425
California	1061072	29660164	1351.84896	21940.44222	0.0357743133	784.9042544
Rhode Island	61942	1048319	64.37376	16284.88067	0.0590869764	962.2243597
New York	267597	17221925	204.386688	84261.48087	0.0155381585	1309.268244
Mississippi	97325	588047	70.811136	8304.442397	0.1655054783	1374.430711
Alabama	186906	712381	85.295232	8351.943987	0.2623680306	2191.283095
New Hampshire	50197	1006649	20.921472	48115.59148	0.0498654447	2399.305364

Table 3: Marine Debris and Population Data, 2010

State	Total Marine Debris	Coastal Population	Km of Coastline	Population Density (per sq Km)	Marine Debris Per Capita	Marine Debris Per Km
Alaska	17388	598207	10686.04416	55.98021036	0.0290668615	1.6271690
Oregon	9298	1982081	476.365824	4160.837953	0.0046910293	19.5186127
Louisiana	21751	3573854	638.909568	5593.677383	0.0060861468	34.0439416
Washington	28173	5229486	252.667008	20697.14618	0.0053873363	111.5024879
Maine	49800	1238956	366.930432	3376.54196	0.0401951320	135.7205499
Hawaii	165254	1360301	1207.008	1127.002472	0.1214834070	136.9121000
N Carolina	86844	2254172	484.412544	4653.413765	0.0385258978	179.2769429
Florida	606786	18427589	2172.6144	8481.757739	0.0329281275	279.2884002
Texas	188364	8287623	590.629248	14031.85336	0.0227283505	318.9208808
Massachusetts	103358	6318177	308.994048	20447.56862	0.0163588326	334.4983525
S Carolina	120111	1932243	300.947328	6420.53549	0.0621614362	399.1097073
New Jersey	101588	8683202	209.21472	41503.78138	0.0116993708	485.5681283
Delaware	28271	897934	45.061632	19926.79715	0.0314844966	627.3851777
California	886147	32258738	1351.84896	23862.67916	0.0274699835	655.5074022
Pennsylvania	95921	6388180	143.231616	44600.34857	0.0150153878	669.6915296
Mississippi	47746	628502	70.811136	8875.750842	0.0759679365	674.2724760
Virginia	131871	5425647	180.246528	30101.25665	0.0243051197	731.6146472
Connecticut	93432	3574097	128.74752	27760.51143	0.0261414282	725.6994154
Alabama	68585	764613	85.295232	8964.311159	0.0896989719	804.0894947
Maryland	55532	5287553	49.889664	105984.9391	0.0105024006	1113.0962918
New York	347654	17586787	204.386688	86046.63627	0.0197679087	1700.9620509
Rhode Island	131598	1052567	64.37376	16350.87029	0.1250257703	2044.2801539
New Hampshire	46726	1073438	20.921472	51307.95768	0.0435292956	2233.3992560

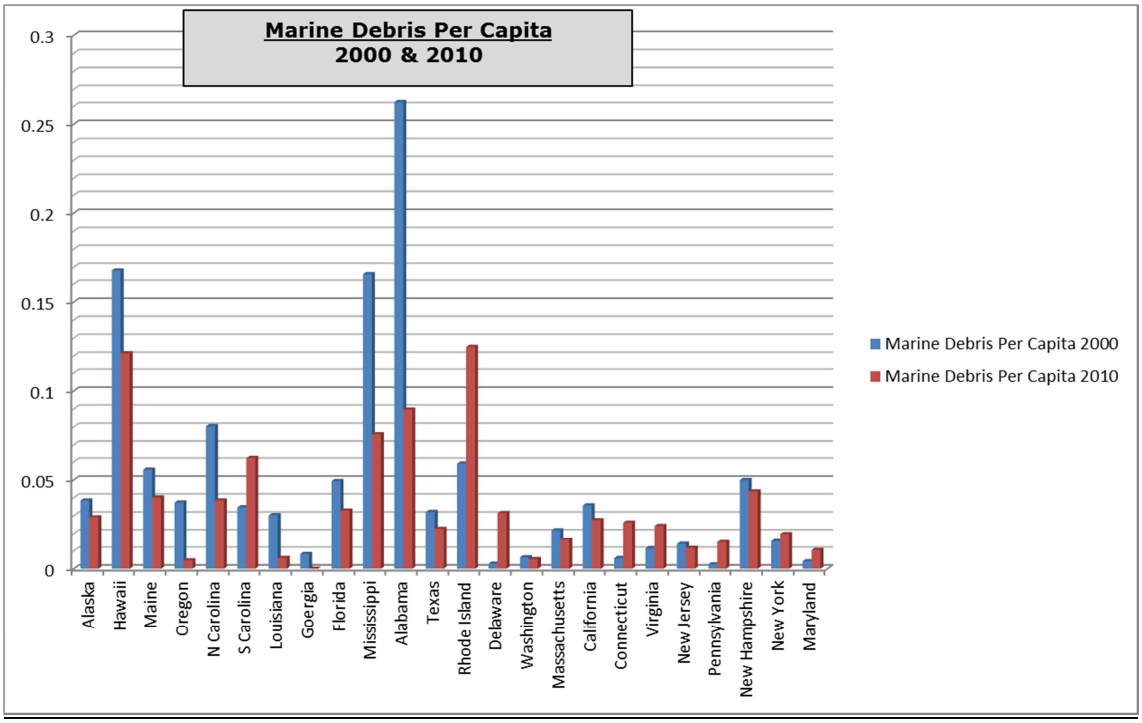

Figure 4: Marine Debris Per Capita, 2000 and 2010. For each coastal state analyzed in this study, the pieces of marine debris per capita are represented here for the years 2000 and 2010. The order of the states on the x-axis is from smallest population density (Alaska) to largest population density (Maryland) (with the exceptions of S Carolina and Washington which had a slight increase in population from 2000 to 2010 but were left in the same order for both years to keep the graph consistent) to ascertain whether there was any correlation between coastal population density (per square kilometer) and marine debris per capita.

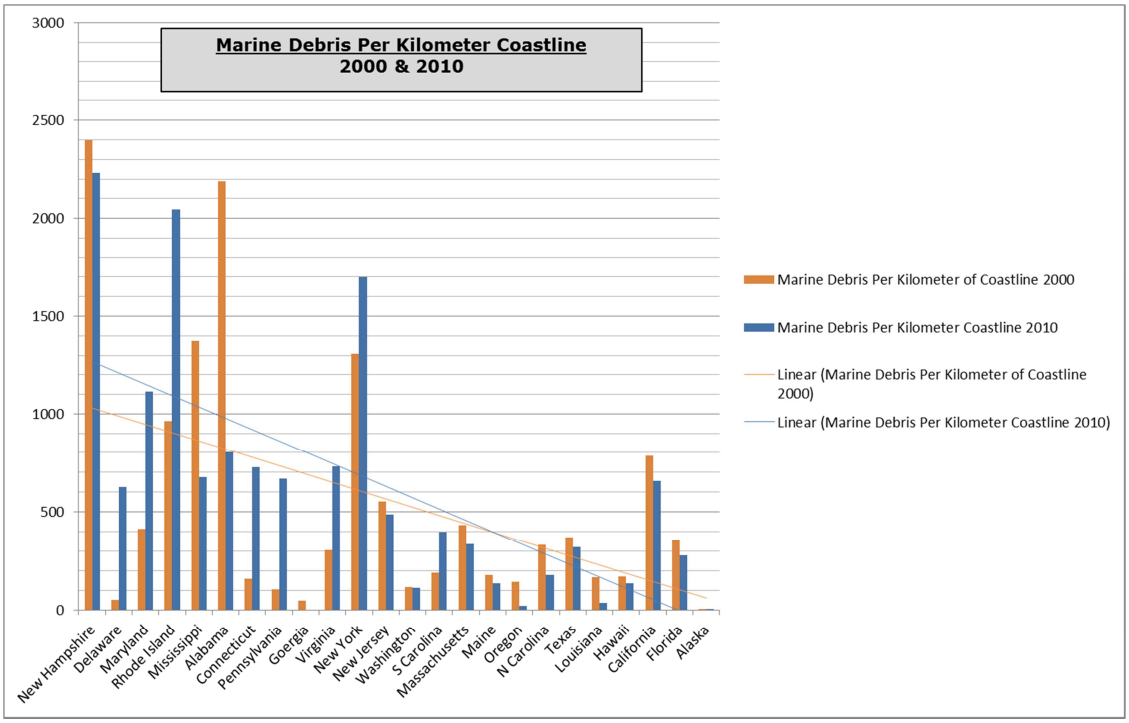

Figure 5: Marine Debris Per Kilometer Coastline, 2000 and 2010. For each coastal state analyzed, pieces of debris per kilometer were calculated. The order of the states on the x-axis is from smallest coastal length (NH) to longest (AK). Trend lines were added to help illustrate any trends.

There is no significant correlation between coastal population and marine debris pieces per capita in the years 2000 or 2010 (Figure 4). However, you can visualize from the trend lines on figure 5, that as the length of coastline increases, the pieces of marine debris found per kilometer did in fact decrease.

However, even though there may not be strong correlations between marine debris amounts and either coastal population density or kilometers of coastline, there are still some interesting data specifics. There is an overall trend of decreasing marine debris per capita from 2000 to 2010 for most states studied. Out of the 24 states analyzed, 16 of them (AL, HI, ME, OR, NC, LA, FL, MI, AL, TX, WA, MA, CA, NJ, NH, and NY) had decreases in

marine debris per capita from 2000 to 2010. This could be for several reasons, including but not limited to, better record keeping, a decrease in the number of volunteers, more public awareness regarding the impacts of litter and marine debris, and more public programs in place to prevent debris from entering the marine environment. Each year the ICC volunteer data collection card changes slightly to help the volunteers better record debris data (The Ocean Conservancy, 2011). Because of these changes, it may be easier for volunteers to record the different types of marine debris found from year to year, making the data more accurate. The number of volunteers could also greatly influence the data collected at the ICC. However, the number of volunteers was not available for the 2000 ICC making it impossible to compare 2000 and 2010 data with respect to volunteer participation-this could have a crucial influence on the data collected and should be considered for future study.

Public programs and public awareness campaigns are generally undertaken at the local and/or state level (Porter, B.E., et al, 1995), and because of this, it is necessary to look at debris data at the state level. OR, LA, AL, MS, and NC had the largest decreases in marine debris per capita from 2000 to 2010, with decreases of 87%, 79%, 65%, 54%, and 52% respectively. Oregon has a Youth Litter Patrol Program that hires teens ages 16-18 to work under a crew leader and remove litter from roadways for an hourly pay (Oregon Office of Maintenance and Operations, 2012). However statistics on the amount of litter cleaned up in OR are not available to the public. LA has an adopt-a-road program administered by the Department of

Transportation (DOT) that recruits volunteers to pick up litter on roadways and the DOT properly disposes of the litter. However, statistics are also not available to the public for this LA program (Louisiana Department of Transportation, 2011). AL has an adopt-a-mile program that is a joint effort between the DOT and Alabama P.A.L.S. (People Against a Littered State) that has recruited volunteers to adopt over 1,600 miles of road ways. This program provides supplies to volunteers to clean up their adopted mile and the program also picks up the filled trash bags to be disposed of properly (Alabama PALS, 2012). MS has an anti-litter program that focuses on education and enforcement, but does not provide statistics for the effectiveness of their program (Mississippi Department of Transportation, 2011). This is most likely a result of public education being extremely hard to quantify, even when very effective (Florida Center for Solid and Hazardous Waste Management, 2002). The NC affiliate of Keep America Beautiful, Keep North Carolina Beautiful, facilitates NC's adopt-a-road program and report that approximately 12,000 miles of roadways have been adopted by volunteers (Keep NC Beautiful, 2012). These state programs, while not always providing data, may be very effective at removing litter from roadways and therefore preventing it from becoming marine debris (Trash Travels, 2010). If these programs had better record keeping and/or provided data to the public, it may illuminate the reasons why these states had very large decreases in marine debris per capita from 2000 to 2010.

In addition to litter prevention programs such as adopt-a-road programs, Gulf of Mexico states, including MS, LA, and AL, may have had a

decreased amount of marine debris found in 2010 as a result of the British Petroleum (bp) oil spill in April of 2010. After the oil spill many paid and volunteer workers were mobilized to help clean up the beaches of the Gulf. Along with oil, they would have also encountered marine debris, much of which would have been contaminated by oil and would have been removed from the beach because it was deemed hazardous (bp, 2010). The removal of so much debris soon after the oil spill may have led to less debris being found in MS, AL, and LA, in September of 2010 during the ICC.

On the opposite end of the spectrum, RI saw a 52% increase in marine debris per capita from 2000 to 2010, MD saw a 59% increase, and DE a 91% increase. RI and DE both have adopt-a-road programs, with the RI DOT reporting approximately 212 miles adopted (State of Rhode Island Department of Transportation, 2012) and DE reporting approximately 1,600 miles adopted (State of Delaware Department of Transportation, 2011). While it is admirable that these states have this program, it is worth noting that the miles adopted in RI and DE are much lower than the 12,000 miles adopted in NC, a state with a major reduction in marine debris per capita from 2000 to 2010 that was not impacted by the bp Gulf oil spill. It may be that DE and RI simply need to increase the miles adopted in order to see a decrease in marine debris. RI has many coastal activities that contribute to the state and local economies including tourism, recreational boating, commercial fishing, transportation, renewable energy production, and much more (U.S. Army Corps of Engineers, 2009). Large changes in marine debris per capita should be further researched to uncover any underlying

contributions to marine debris amounts so the respective state(s), such as RI, can reduce marine debris and better their coastal environment and economy.

Fourteen of the 24 states studied saw a decrease in marine debris per kilometer from 2000 to 2010, but ten states saw increases over the ten year period. The four states with the smallest coastlines are NH, DE, MD, and RI. NH's marine debris per kilometer amount changed very little from 2000 to 2010, only increasing less than 200 pieces per kilometer. DE, MD, and RI saw significant increases in marine debris per kilometer coastline, with a 92%, 63%, and 53% increase respectively. This is in line with their increases in marine debris per capita of 91% for DE, 59% for MD, and 52% for RI. If there is more debris per capita, but still a small coastline, there is a smaller area for the debris to be deposited into the marine environment, increasing the debris per kilometer found. These three states have very small coastlines in comparison to states like FL and CA, all three under 65 kilometers in length, but do rely on coastal activities to contribute to their economies. The states should be concerned about increases in marine debris because it can impact marine organisms and therefore ecotourism (Population Trends Along the Coastal United States, 2005), it can expose coastal tourists to human health hazards also impacting the tourism economy (Tudor, D., & Williams, A., 2003), and can impact commercial fisherman and transportation by getting caught in gear or fouling boat props which would also impact the state economies (Information on Marine Debris, 2010).

The states with the longest coastline, AK, HI, CA, and FL had fairly stable per capita debris amounts, with a decrease of 24% for AK, a decrease of 28% for HI, a decrease of 23% for CA, and a decrease of 33% for FL from 2000 to 2010. These states also had fairly stable marine debris per kilometer amounts with a decrease of 14% for AK, a decrease of 19% for HI, a decrease of 16% for CA, and a decrease of 21% for FL from 2000 to 2010. It's also worth noting that AL, LA, and MS saw drastic reductions in marine debris per kilometer from 2000 to 2010, a 63%, 80%, and 51% reduction respectively. These large reductions for AL, LA, and MS could be related to debris cleanup in the aftermath of the bp oil spill, leaving less debris to be found during the 2010 ICC. For more data regarding the change in debris amounts from 2000 to 2010 please see table 4.

Table 4: Changes in Marine Debris, 2000-2010.

Changes from 2000 to 2010

State	Population Density (Per sq KM)	Marine Debris/Capita	Marine Debris/KM	Key
Alaska	6.73795	-0.0094390440	-0.2689489166	
Louisiana	60.86151	-0.0242380230	-133.7341062	Top five decreases (%) in marine
Rhode Island	65.98962	0.0659387939	1082.0557942	debris from 2000 to 2010
Hawaii	123.25022	-0.0466567324	-31.8589438	
Maine	150.45359	-0.0155320063	-44.0601231	Top three increases (%) in marine
Oregon	365.51741	-0.0326681837	-122.2715759	debris from 2000 to 2010
N Carolina	517.12740	-0.0418646258	-153.2412835288	
Mississippi	571.30845	-0.0895375418	-700.1582349985	Gulf of Mexico States
Alabama	612.36717	-0.1726690587	-1387.1936006927	
Massachusetts	624.17384	-0.0054717324	-98.2575560808	
S Carolina	926.73027	0.0274524279	208.4251766475	
Florida	1276.12889	-0.0164230309	-76.3177303805	
Connecticut	1309.01162	0.0201623909	567.5449127098	
New Jersey	1774.67914	-0.0022413430	-68.2839142485	
New York	1785.15540	0.0042297502	391.6938073775	
California	1922.23693	-0.0083043298	-129.3968521454	
Texas	2434.26651	-0.0093821672	-53.4836364893	
Pennsylvania	2496.64152	0.0124857812	563.1857145283	
Delaware	2537.28050	0.0285786773	576.8543846792	
Washington	2542.13245	-0.0010314318	-5.0303362123	
New Hampshire	3192.36620	-0.0063361491	-165.9061083274	
Virginia	3506.20346	-0.0357967422	-1037.2349585563	
Maryland	8479.57204	0.0062487348	698.3410431467	

Table 4 shows the changes in coastal population density, marine debris per capita, and marine debris per kilometer coastline for all states (except Georgia which did not participate in the 2010 ICC). Major increases and decreases are highlighted with a key in the far right column. The table is organized from smallest change in population density to largest change.

So, while there may not have been significant correlation between marine debris amount and population density, and marine debris amounts and length of coastline, there are some interesting facts within the data. Additionally, there are other factors that could have potentially influenced marine debris amounts in the states studied as part of this project. Other factors could include hydrology and river connectivity, level of urbanization or amount of impermeable surface (since most marine debris is land based), level of participation in roadside litter prevention and/or cleanup (i.e. number of volunteers), and/or whether an area has treated storm water or simply allows the rain to drain unchecked into coastal waters. All of these factors could influence marine debris amounts, and could potentially be more strongly related to debris amounts than coastal population density and length of coastline.

Pieces of debris per capita and per kilometer coastline were mapped in GIS to ascertain whether there was a geographical pattern (Figures 6, 7, 8 & 9). For example, does the Northeast or the Gulf of Mexico as a region have a marine debris pattern?

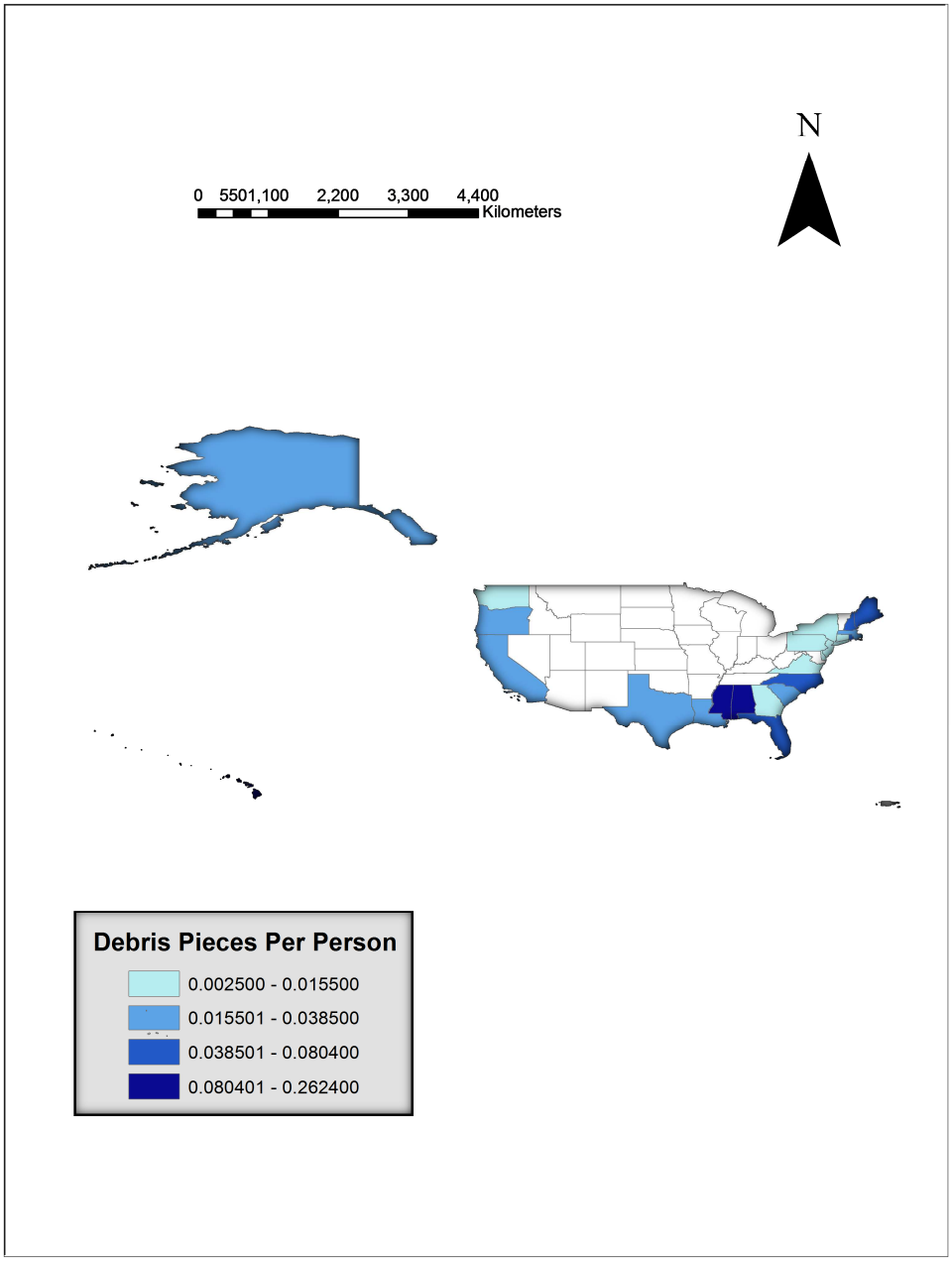

Figure 6: Marine Debris Per Capita, 2000. Map of marine debris per capita for the year 2000. Natural breaks (Jenks) were used in ArcGIS to group inherently similar ranges within the data together. Jenks maximizes the differences between classes, keeping states that have similar data within the same grouping.

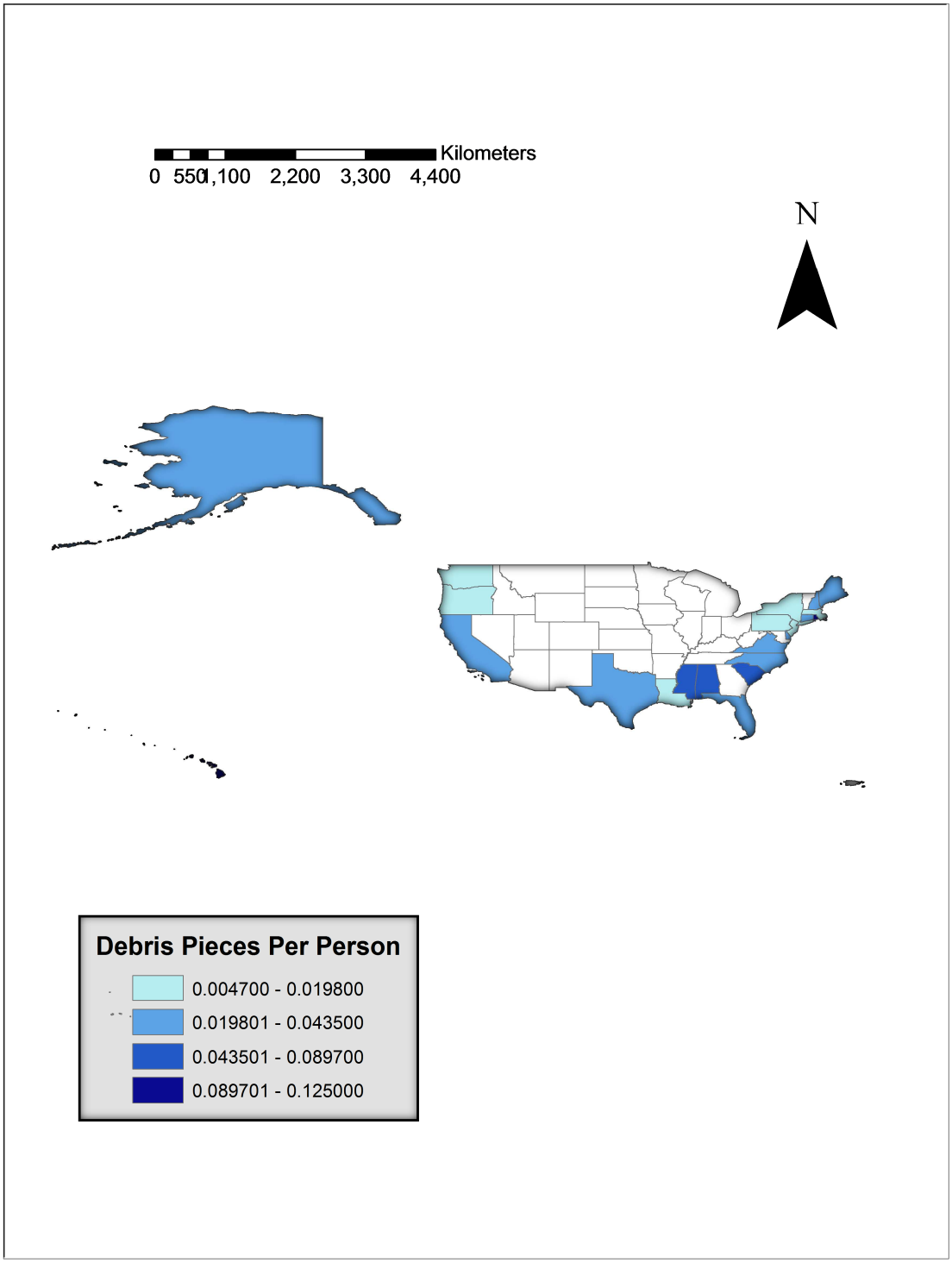

Figure 7: Pieces of Marine Debris Per Capita, 2010. Same data grouping classification was used as in figure 6.

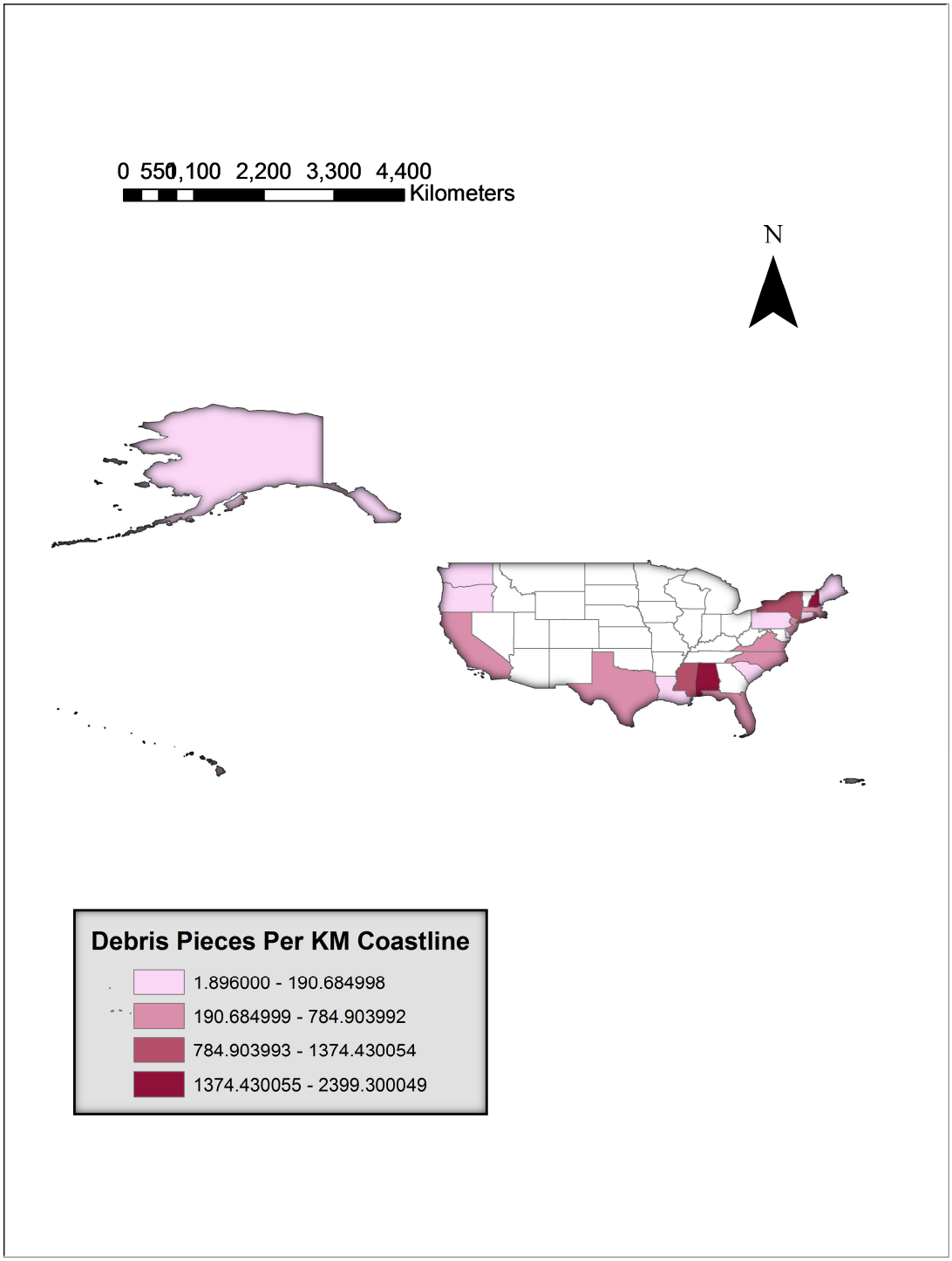

Figure 8: Pieces of Marine Debris per Kilometer Coastline, 2000. The same data classification, Natural Breaks (Jenks), was used as in figures 6 and 7.

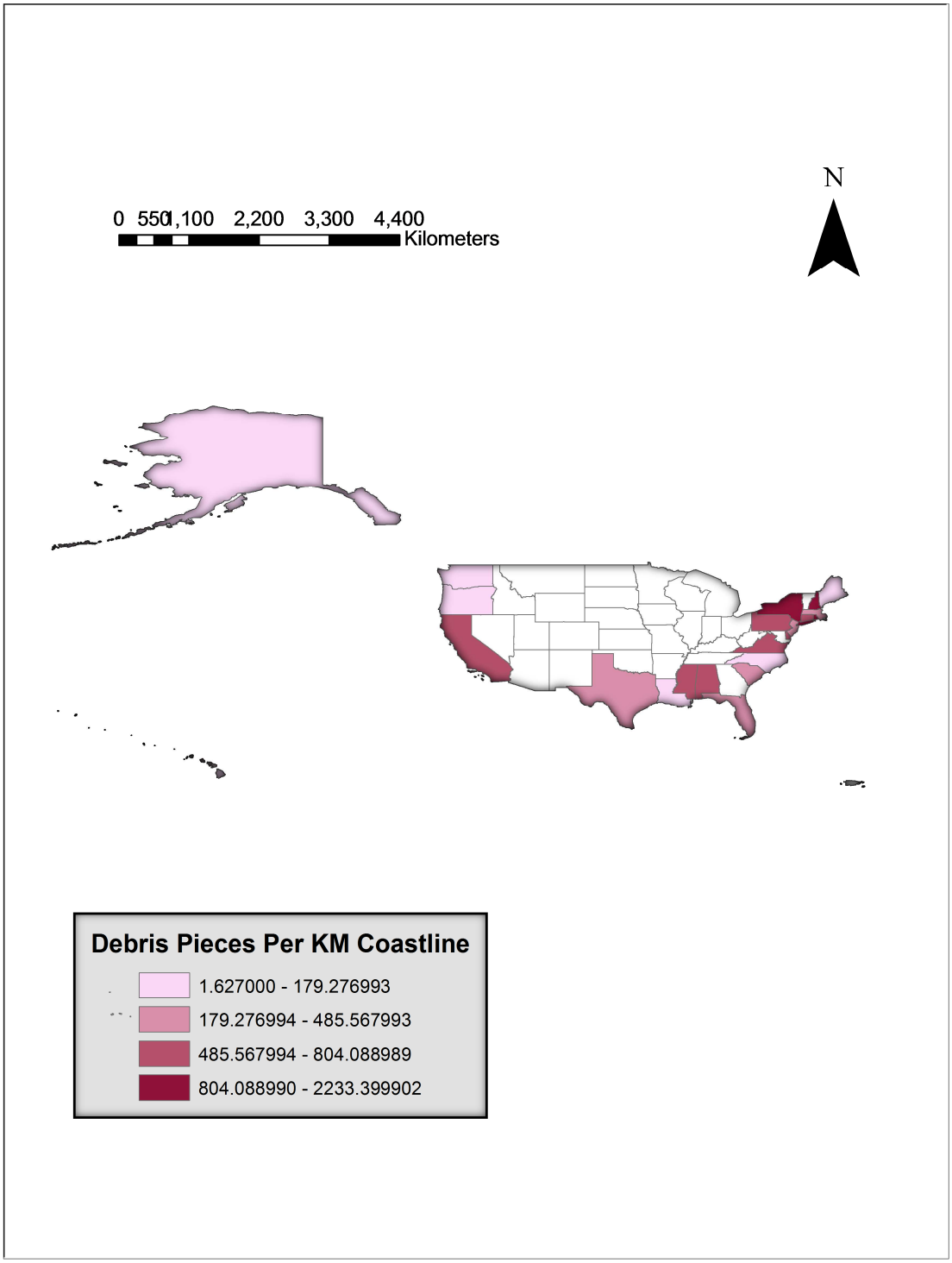

Figure 9: Pieces of Marine Debris per Kilometer Coastline, 2010. Natural Breaks were again used to classify the data.

A geographical pattern may show up if, for example, ocean currents/circulation and/or regional wind patterns, had the greatest influence on marine debris amounts. From these maps it is evident that there is no geographical pattern of marine debris per capita or per kilometer coastline, supporting an assumption that ocean circulation and/or regional wind patterns are not the primary influence on marine debris amounts. These maps do however make it easier to visualize length of coastline and marine debris per kilometer data.

Bottle Bill Results

Following, in tables five and six, is the returnable debris data for 2000 and 2010. In addition, averages are shown in graph format to help illustrate bottle bill states as compared to non-bottle bill states. Finally, a t-test table shows the result of the t-test performed.

Table 5: Marine Debris and Bottle Bill Status, 2000.

State (Bottle Bill)	Total Debris	Total # of Returnable Debris	Coastal Population	KM of Coastline	Pop Density (per Sq Km)	Returnable Debris/Capita	Returnable Debris/Km Coastline
California	1061072	56,501	29660164	1351.84896	21940.44222	0.0019049456	41.79534968
Massachusetts	133719	10096	6125311	308.994048	19823.39479	0.0016482428	32.67376853
Rhode Island	61942	7510	1048319	64.37376	16284.88067	0.0071638499	116.6624413
Oregon	67544	3900	1807961	476.365824	3795.320548	0.0021571262	8.186985303
New York	267597	28618	17221925	204.386688	84261.48087	0.0016617190	140.0189038
Connecticut	20362	1518	3405565	128.74752	26451.4998	0.0004457410	11.79051837
Maine	65967	4510	1183750	366.930432	3226.088372	0.0038099261	12.29115823
Delaware	47122	6608	783600	45.061632	17389.51665	0.0084328739	146.6436014
Averages	215665.625000	14907.625000	7654574.375000	368.338608	24146.577990	0.003403	63.757841
State (Non-Bottle Bill)							
Florida	772595	90734	15655053	2172.6144	7205.62885	0.0057958284	41.76258797
N Carolina	161076	35836	2003669	484.412544	4136.286363	0.0178851896	73.97826593
S Carolina	57386	6070	1653346	300.947328	5493.805215	0.0036713428	20.16964244
Texas	219953	22004	6849874	590.629248	11597.58685	0.0032123219	37.25518178
New Jersey	115874	9440	8311913	209.21472	39729.10224	0.0011357193	45.12110811
Maryland	20692	2801	4864510	49.889664	97505.36704	0.0005758031	56.14389385
Washington	29444	3712	4587173	252.667008	18155.01373	0.0008092130	14.69127303
Georgia	7546	1163	915957	160.9344	5691.492931	0.0012697103	7.226546966
Averages	173070.750000	21470.000000	5605186.875000	527.663664	23689.285403	0.004294	37.043563

Table 5 presents total debris amounts, total returnable debris amounts, coastal population, population density, and returnable debris per capita and per kilometer coastline for eight states with a bottle bill and eight states without a bottle bill.

Table 6: Marine Debris and Bottle Bill Status, 2010

State (Bottle Bill)	Total Debris	Total #s of Returnable Debris	Coastal Population	KM of Coastline	Pop Density (per Sq Km)	Returnable Debris/Capita	Returnable Debris/Km Coastline
California	886147	75,106	32258738	1351.84896	23862.67916	0.0023282374	55.55798186
Massachusetts	193458	14069	6318177	308.994048	20447.56862	0.0022267499	45.53162137
Rhode Island	131600	17703	1052567	64.37376	16350.87029	0.0168188818	275.0033554
Oregon	9298	974	1982081	476.365824	4160.837953	0.0004914027	2.044647099
New York	347654	55063	17586787	204.386688	86046.63627	0.0031309301	269.4059997
Connecticut	93432	12460	3574097	128.74752	27760.51143	0.0034861953	96.77856319
Maine	49800	4368	1238956	366.930432	3376.54196	0.0035255489	11.90416389
Delaware	28271	3649	897934	45.061632	19926.79715	0.0040637731	80.97798145
Averages	217457.500000	22924.000000	8113667.125000	368.338608	25241.555353	0.004509	104.650539
State (Non-Bottle Bill)							
Florida	606786	86408	18427589	2172.6144	8481.757739	0.0046890562	39.7714385
N Carolina	86844	19855	2254172	484.412544	4653.413765	0.0088081122	40.98779077
S Carolina	120111	23787	1932243	300.947328	6420.53549	0.0123105634	79.04040936
Texas	188364	39058	8287623	590.629248	14031.85336	0.0047128109	66.12947146
New Jersey	101083	10737	8683202	209.21472	41503.78138	0.0012365254	51.3204807
Maryland	55532	11428	5287553	49.889664	105984.9391	0.0021613022	229.0654834
Washington	28173	4591	5229486	252.667008	20697.14618	0.0008779065	18.17016015
Averages	169556.142857	27980.571429	7157409.714286	580.053559	28824.775286	0.004971	74.926462

Table 6 presents the same data as table 4, but for the year 2010.

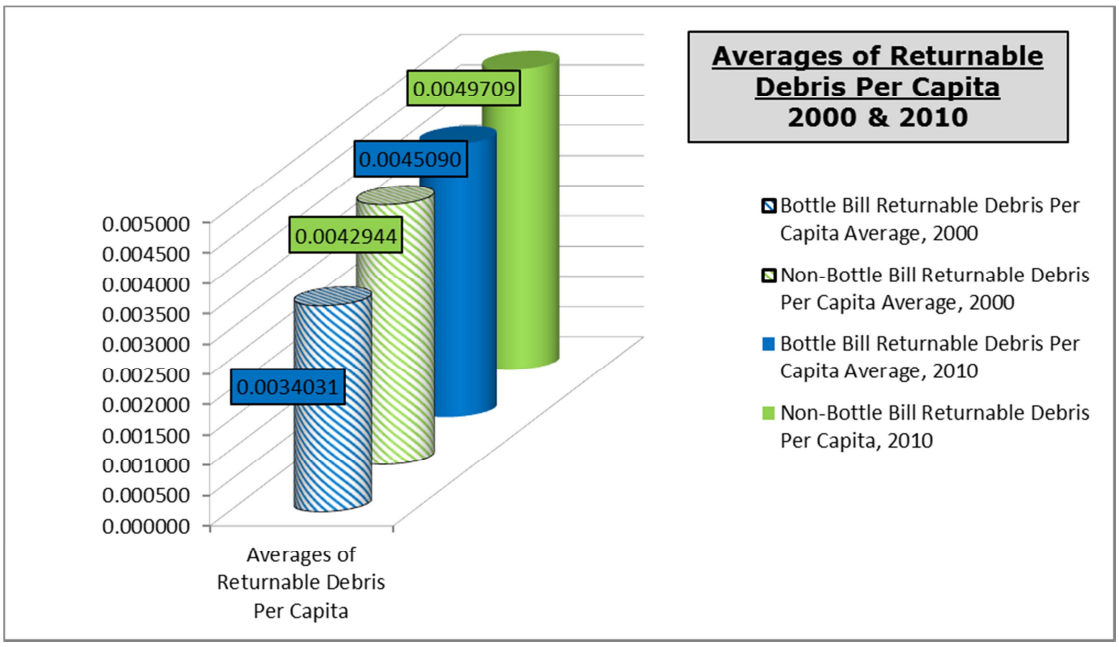

Figure 10: Returnable Debris Per Capita Averages for Bottle Bill and Non-Bottle Bill States for 2000 and 2010. The averages were plotted on a bar graph to help illustrate any similarities or differences in per capita debris between bottle bill and non-bottle bill states.

Table 7: Bottle Bill T-Test.

2000	Bottle Bill States	Non-Bottle Bill States	df	p=0.05	T-Test	Significantly Different?
Average Returnable Debris Per Capita	0.003403053	0.004294391	14	2.14	0.702103351	NO
Average Total Debris	215665.625	13990.287861	14	2.14	0.784570524	NO
Average Returnable Debris per KM	63.75784083	37.043563	14	2.14	0.258916659	NO

2010	Bottle Bill States	Non-Bottle Bill States	df	p=0.05	T-test	Significantly Different?
Average Returnable Debris Per Capita	0.004508965	0.004970897	13	2.16	0.852802421	NO
Average Total Debris	53932.347688	3506.835172	13	2.16	0.720542941	NO
Average Returnable Debris per KM	104.6505392	74.92646205	13	2.16	0.546486367	NO

Table of the bottle bill t-test to determine if debris per capita and per kilometer coastline are significantly different for bottle bill and non-bottle bill states.

There was no significant difference in the amount of returnable debris per capita or per kilometer coastline found in states with bottle bills versus states without bottle bills (table 7). Perhaps returnable debris amounts could be more impacted by state recycling rates overall than just the status of and participation in a bottle bill. However, it is worth noting that bottle bill states did have slightly lower amounts of returnable debris per capita (0.0008913 or 20% per capita less in 2000, and 0.0004619 or 9% per capita less in 2010). Most returnable debris is plastic-the most harmful of debris types (Marine Debris Reports Submitted to Congress, 2008), so any lessening of returnable debris should be seen as beneficial to the marine environment. If the average amount of returnable debris found in bottle bill states is extrapolated to see the possible effect on national returnable debris amounts (figure 11), the outcome could be quite significant for the marine environment, with a possible returnable debris reduction of 10% nationally.

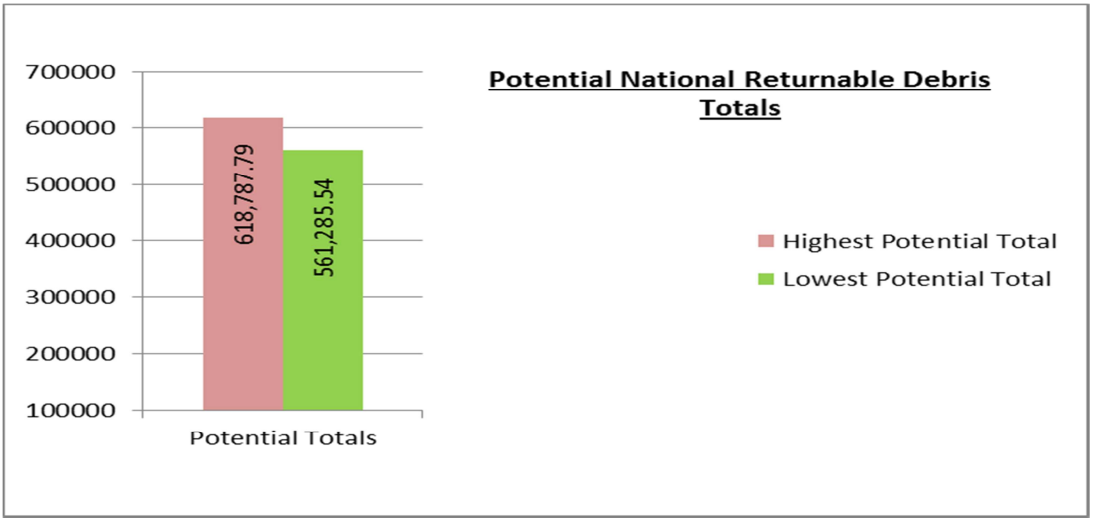

Figure 11: Potential National Returnable Debris Totals. These numbers were obtained by multiplying the average per capita returnable debris for non-bottle bill states (pink) and bottle bill states (green) by the total US coastal population for the study area.

Monofilament Line Results

The results for monofilament fishing line debris are presented in table and graph format. In addition, there is a table that shows the t-test performed to ascertain whether there was a difference between Florida and the national average of fishing line debris.

Table 8: Monofilament Fishing Line Data

	Total Debris	Fishing Line Debris	Coastal Population	Per Capita Fishing Line Debris
FL 2000	772595	5379	15655053	0.000343595
FL 2010	606786	11387	18427589	0.000617932
National Coastal Average 2000	1583742	1053	5186755	0.000203017
National Coastal Average 2010	153122	146627	5711588	0.025671845

Total debris, fishing line debris, and fishing line per capita data for the nation and Florida for years 2000 and 2010 are presented in table 8. Total debris and fishing line debris are number of pieces found.

Table 9: Monofilament Line T-Test.

df	p=0.05	t-test	Significantly different?
2	4.3	0.431158985	NO

To test if there is a significant difference between Florida's monofilament line debris averages for both years, and the national averages for both years.

In 2000, only one year after FL began the voluntary monofilament line recycling program (Florida Fish and Wildlife Conservation Commission, 2009), FL was actually 80% higher than the national coastal average for pieces of fishing line found during the 2000 ICC. In 2010, the national coastal average was 92% higher than the FL fishing line debris amount. However, the number of samples, being only two per year, is very small and according to the student's t-test, there was no significant difference between FL and the national coastal average of fishing line debris when combining years (the students t-test requires a sample number of three or higher so the

years could not be compared separately). It could be that monofilament line debris is strongly correlated to another variable, such as number of licensed fisherman, which was unavailable for the year 2000 and therefore population was instead used for both years. However, even though the difference was not significant according to the student's t-test, Florida did have less monofilament line per capita than the national average in 2010. If these 2010 numbers are extrapolated, similar to what was done with the returnable debris data, there is the possibility that increased monofilament line recycling could reduce line debris up to 97% nationally (figure 12).

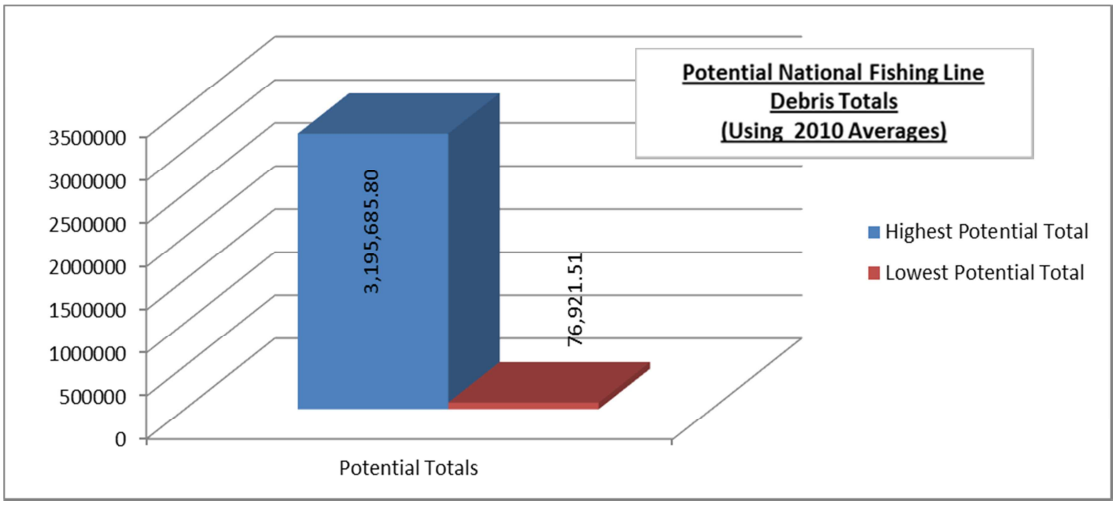

Figure 12: Potential National Fishing Line Debris Totals. Totals were obtained by multiplying the 2010 per capita data for fishing line for the US (blue) by coastal population, and for Florida (pink) by the coastal population.

If all coastal states had the high level of participation that Florida has (46 out of 67 counties have a total of 1061 line recycling bins (Florida Fish and Wildlife Conservation Commission, 2009)), the amount of line being recycled would increase, decreasing the amount that ends up in the marine environment. With a significant decrease in fishing line debris, the marine environment would be much less hazardous for marine wildlife. Fishing line

is the number one debris item that causes entanglement for marine wildlife (Trash Travels, 2010), and once entangled, an animal can have trouble breathing, infection at the entanglement site, trouble flying, loss of limb because growth is impeded, and it can also cause death (The Ocean Conservancy, 2010). In addition, fishing line can get wrapped around docks, boat props, entangled in fishing nets, and cause other problems for fisherman, both recreational and commercial (Marine Debris Reports Submitted to Congress, 2008). These environmental and economic hazards could be reduced with increased line recycling.

Cigarette Butt Results

Cigarette butt debris data is provided in table and graph format, and the number of cigarette butts per smoker is calculate for both 2000 and 2010 to ascertain whether there is a reduction in cigarette but debris over the ten year time span that is not related to a reduction in smokers.

Table 10: Cigarette Butt Debris Data, 2000.

State	Population 2000	% Adult Smokers	# Adult Smokers	KM of Coastline	Cigarette Butt Debris	Butts per Smoker
Georgia	8186453	23.6	1932003	160.9344	848	0.000438923
Pennsylvania	12281054	24.3	2984296	143.231616	2,870	0.000961701
Washington	5894121	20.7	1220083	252.667008	2,049	0.001679394
Maryland	5296486	20.6	1091076	49.889664	2,089	0.001914624
Virginia	7078515	21.5	1521881	180.246528	3,853	0.002531736
Texas	20851820	22	4587400	590.629248	17,967	0.003916597
New York	18976457	21.6	4098915	204.386688	24,350	0.005940597
N Carolina	8049313	26.1	2100871	484.412544	14,983	0.007131805
Connecticut	3405565	20	681113	128.74752	5,990	0.008794429
Louisiana	4468976	24.1	1077023	638.909568	11,496	0.010673865
New Jersey	8414350	21	1767014	209.21472	20,430	0.011561881
Oregon	3421399	20.8	711651	476.365824	11,834	0.016628938
S Carolina	4012012	24.7	990967	300.947328	18,862	0.019033934
Massachusetts	6349097	20	1269819	308.994048	33,597	0.026458093
Mississippi	2844658	23.5	668495	70.811136	17,691	0.026463937
Delaware	783600	23	180228	45.061632	5,568	0.030894201
Maine	1274923	23.8	303432	366.930432	9,656	0.03182265
Alaska	626932	25	156733	10686.04416	5,128	0.032718062
Rhode Island	1048319	23.5	246355	64.37376	8,764	0.035574684
California	33871648	17.2	5825923	1351.84896	222,523	0.038195318
New Hampshire	1235786	25.4	313890	20.921472	13,733	0.043751045
Florida	15982378	23.2	3707912	2172.6144	172,297	0.046467396
Alabama	4447100	25.3	1125116	85.295232	61,721	0.05485744
Hawaii	1211537	19.7	238673	1207.008	47,375	0.198493512
Nationally	281421906	23.3	65571304	19928.51	812,153	0.012385799

Table 10 shows population, smoker, and cigarette butt debris data for the year 2000 for coastal states. It is organized by butts found per smoker, from smallest number to largest.

Table 11: Cigarette Butt Debris Data, 2010.

State	Population 2010	% Adult Smokers	# Adult Smokers	KM of Coastline	Cigarette Butt Debris	Butts per Smoker
Texas	25145561	18.5	4651929	590.629248	18818	0.004045204
Louisiana	4533372	20.5	929341	638.909568	4295	0.004621553
Oregon	3831074	16.3	624465	476.365824	2939	0.004706428
Washington	6724540	15.7	1055753	252.667008	6352	0.00601656
Pennsylvania	12702379	21.3	2705607	143.231616	31590	0.011675755
N Carolina	9535483	20.9	1992916	484.412544	27388	0.013742677
Virginia	8001024	16.4	1312168	180.246528	19107	0.014561398
Alabama	4779736	22.1	1056322	85.295232	15877	0.01503046
Maryland	5773552	14.9	860259	49.889664	13615	0.015826624
Mississippi	2967297	22.7	673576	70.811136	11332	0.016823629
New Jersey	8791894	14.8	1301200	209.21472	24518	0.018842602
New York	19378102	16.8	3255521	204.386688	65386	0.020084649
Alaska	710231	21.5	152700	10686.04416	4079	0.026712567
Massachusetts	6547629	16.1	1054168	308.994048	30365	0.028804699
Connecticut	3574097	15.9	568281	128.74752	30057	0.052891048
S Carolina	4625364	20	925073	300.947328	58787	0.063548512
California	37253956	14	5215554	1351.84896	335320	0.064292309
Florida	18801310	17.5	3290229	2172.6144	214248	0.065116435
Delaware	897934	17.8	159832	45.061632	11093	0.069404015
Maine	1328361	18.2	241762	366.930432	22730	0.0940182
New Hampshire	1316470	17.1	225116	20.921472	23059	0.102431467
Rhode Island	1052567	17.4	183147	64.37376	43623	0.238186164
Hawaii	1360301	15.4	209486	1207.008	67070	0.320164052
Georgia	9687653	19.5	1889092	160.9344	n/a	n/a
Nationally	308745538	19.3	59587889	19928.51	1181589	0.019829348

Table 11 shows the same data as table 9 but for 2010. Georgia did not participate in the 2010 ICC.

Table 12: Cigarette Butt Debris Test, 2000-2010.

df	p=0.05	t-test	Significantly different?
47	2.02	0.1252459	No

Table 13: National Change in Smoking and Cigarette Debris Data, 2000-2010.

Population	% Smokers	# Smokers	Cigarette Butt Debris	Butts Per Smoker
27323632	-4	-5983415	369,436	0.007443549

Negative numbers indicate a loss and positive numbers indicate a growth.

The Keep America Beautiful cigarette butt litter prevention program began in 2002 and has steadily increased in participation nationally. However, there is no significant difference between the amounts of cigarette butts found per smoker in 2000 as compared to 2010. In fact, even with a decrease in the number of adult smokers, there was an increase in cigarette butts found per smoker during the International Coastal Cleanups (see table 13 and figures 13 & 14).

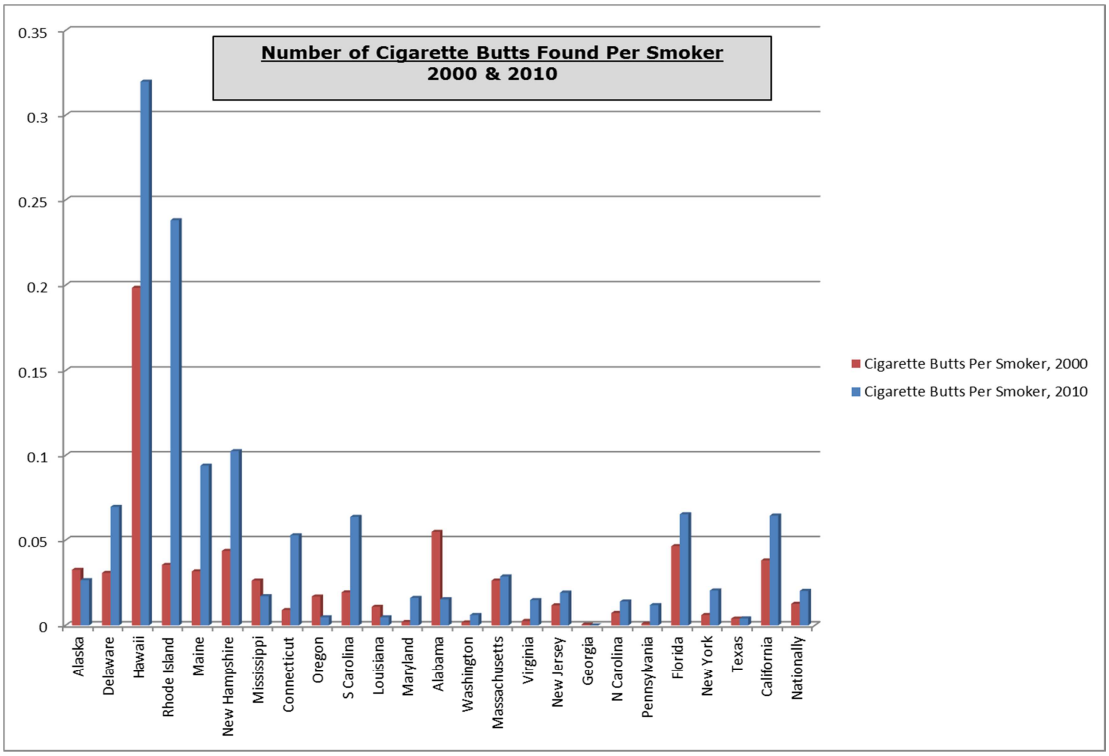

Figure 13: Cigarette Butt Debris Found Per Smoker, 2000 & 2010._ The x-axis is ordered from the smallest number of adult smokers to the largest number of adult smokers reported for the year 2000. The order of the states for the number of smokers reported in 2010 is similar to the order from 2000 with slight changes in Rhode Island, New Hampshire, Connecticut, Oregon, Maryland, and New Jersey, but these states were left in the 2000 order because their order number change was slight and it helped to keep the graph consistent.

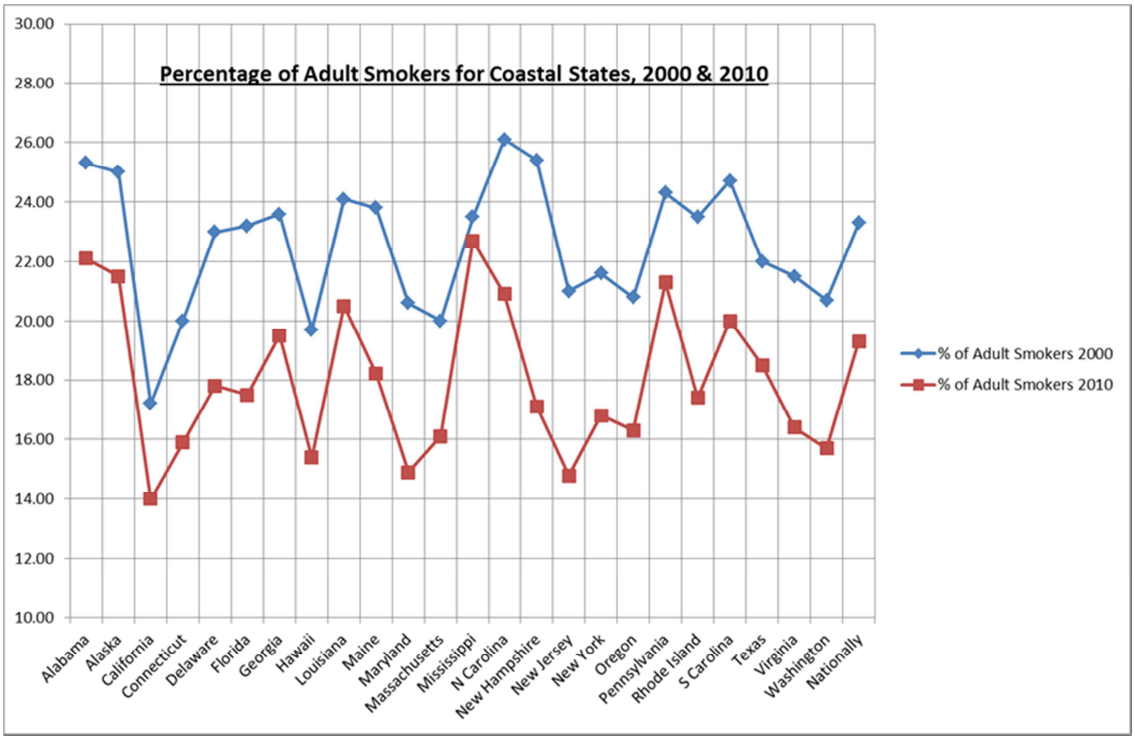

Figure 14: Percentage of Adult Smokers, 2000 and 2010._There is clearly a decrease in the percentage of adult smokers reported from 2000 to 2010.

There may not have been a significant decrease in butts per smoker from 2000 to 2010 as was hypothesized, but there are some interesting findings within the data. HI had a 35% increase in butts per smoker from 2000 to 2010. RI and CT had an 85% and 83% increase in butts per smoker from 2000 to 2010 respectively. In addition, ME, NH, and SC more than doubled their 2000 numbers by the 2010 ICC. In fact, other than the small decrease that AK had, all of the states studied increased the number of butts per smoker found from the 2000 ICC to the 2010 ICC except for AL, MS, and LA. These three states were substantially impacted by the April 2010 bp oil spill in the Gulf of Mexico, and many cleanup workers were mobilized to remove oil, and contaminated debris, from the beaches (bp, 2011). The

cleanup of the spilled oil could have also cleaned up some of the cigarette butt debris, leaving less cigarette butts to be found during the 2010 ICC.

Many cigarette butts become marine debris by washing away with storm water into rivers and eventually marine waters (Marine Debris, 2010). Because of this fact, it would be interesting to see if the states with very high increases in cigarette debris also increased their area of impermeable surfaces (paved roads, sidewalks, parking lots, etc.) over the same ten year time span. For example, did ME increase its impermeable surface area by 50%? If so, this could explain why the increase in cigarette butt marine debris was so drastically high.

Cigarette butts are the number one items found at every cleanup, regardless of the organizer of the cleanup (Keep America Beautiful, Key Findings: Cigarette Butt Litter, 2010). In addition, cigarette butts are non-biodegradable and even when completely smoked, still contains some toxic chemicals (Novotny, T., & Zhao, F., 1999). Because of their toxicity and persistence in the environment, cigarette butts have become a growing concern among environmental groups, including The Ocean Conservancy. Because of this growing concern, there has been a push, which includes more education of cleanup volunteers (Trash Travels, 2010), to clean up more of the cigarette butts, which could have led to the increased amount of cigarette butts found during the 2010 ICC. In addition to increased awareness, a simple increase in volunteers could also cause the increase in cigarette butts found in 2010 versus 2000. Volunteer participation data was

not available for the 2000 ICC and so could not be compared between 2000 and 2010.

Limitations of This Thesis

There are several limitations of this thesis including scale, available data, and using volunteer collected data. Firstly, the scale of this study was either state or national boundaries. This scale was chosen because of the implementation of state and/or national laws/programs, and also because the smallest scale within the ICC data available was the state level. Local environmental and social conditions can greatly impact marine debris amounts, but those differences are blended together into one picture for the state or nation because of the nature of the ICC data and because of this, some crucial difference may be lost in translation. In addition, using volunteer data, while supported by many studies noted in the literature review, can be problematic. The data set was compiled by many different people, which increases the chance of human error, and also means the data collected is outside the control of the researcher. There could be unknown errors within the data collected that may have influenced the results of this thesis.

In addition, because the scale was large, local conditions like proximity of roads to the coast private versus public access to beaches, and substrate of the coastline (rocky shores versus sand shores) was not considered when analyzing the data. These factors could influence marine debris amounts in several ways. For example, an area with mostly private beaches could be

cleaner, a coastline that is sandy may receive more river deposition and therefore could have more debris deposited on the coastline, or close proximity of roads may lead to more roadside litter becoming marine debris. All of these factors could impact marine debris amounts, and because this study did not consider these factors while analyzing the data, it is a limitation of this thesis.

The analysis of the ICC data at state and national levels in this thesis may not have provided statistically significant results, but it did provide some interesting insights to the data and the litter prevention techniques analyzed. Because of the scale used, and the statistically insignificant results, it may appear as though some of the litter prevention programs are not useful, but that is not the case. This study does not wish to convey any idea that the programs are useless, because all of the litter prevention programs do lessen litter amounts, particularly found on roadsides or sidewalks, even if the techniques did not significantly impact marine debris amounts. It could be that by looking at the data on a different scale, or calculating it differently such as per volunteer, could lead to differences in data groupings that are statistically significant and that help to support the role of these litter prevention techniques in marine debris amounts.

CHAPTER 7: CONCLUSIONS

In conclusion, each litter prevention technique had its own set of research questions that this thesis attempted to answer. Below the research questions are restated along with the answer that was uncovered by analyzing the International Coastal Cleanup (ICC) data for 2000 and 2010.

1. Does population density along the coast influence marine debris amounts, and more specifically lead to higher amounts of marine debris? Does length of coastline influence marine debris amounts? The data analysis does not suggest any significant correlation between coastal population density and marine debris amounts. However, in general, with population increase comes increases in urbanization, waste production, impermeable surfaces, and more. Each of those human induced changes could also impact marine debris amounts and are worthy of further study. Interestingly, OR, LA, AL, MS, and NC had the largest decreases in marine debris per capita from 2000 to 2010, with decreases of 87%, 79%, 65%, 54%, and 52% respectively. Alternately, RI saw a 52% increase in marine debris per capita from 2000 to 2010, MD saw a 59% increase, and DE a 91% increase. In addition, DE, MD, and RI (3 of the 4 states with the smallest coastline) saw significant increases in marine debris per kilometer coastline, with a 92%, 63%, and 53% respectively, which is expected since they had

increases in marine debris per capita. The states with the longest coastline, AK, HI, CA, and FL had only minor changes in per capita debris amounts from 2000 to 2010 and they also had only minor changes in marine debris per kilometer amounts.

2. Does the implementation of a state bottle bill lessen the amount of returnable marine debris and/or impact the total amount of marine debris found within the respective states? There was no statistically significant difference of total marine debris or returnable debris between bottle bill and non-bottle bill states. However, it is worth noting that bottle bill states did have slightly lower amounts of returnable debris per capita (0.0008913 or 20% per capita less in 2000 and 0.0004619 or 9% per capita less in 2010). Most returnable debris is plastic, which is the most environmentally harmful type of debris types (Marine Debris Reports Submitted to Congress, 2008). If the average amount of returnable debris found in bottle bill states is extrapolated to see the possible effect of a national bottle bill, the potential decrease in returnable debris could be significant, as much as 10%, or about 60,000 pieces less, nationally, making for a healthier marine environment. The return, or redemption, of plastic beverage bottles also helps to increase the recycling rate of plastic. Plastic, which is made in part of petroleum products, is not a renewable resource and recycling should be maximized to help conserve petroleum resources. According to the U.S. Energy Information Administration (2008), 331 million barrels of liquid petroleum gases

and natural gas liquids, 4.6% of the total U.S. petroleum consumption, were used to produce plastics in 2006 in the U.S. By implementing a national bottle bill, and increasing the return rate of plastic beverage containers, not only could the amount of plastic beverage containers that become marine debris be lessened, but the U.S. could also reduce the amount of petroleum used to produce plastic beverage containers. Therefore, the implementation of a bottle bill in all states could have several positive impacts on the environment as a whole and the economy.

3. Does the implementation of a voluntary monofilament line recycling program in the state of Florida lessen the amount of fishing line debris found in Florida as compared to the nation average? Does the program impact total debris amounts found during the ICC? There was no significant difference between Florida and the national average of fishing line debris, or total debris, for 2000 or 2010. It could be that monofilament line debris is strongly correlated to another variable, such as number of licensed fisherman, which was data that was unavailable for the year 2000 and therefore population was instead used for both years. However, similar to the potential presented in the bottle bill section, if every state participates as heavily in the monofilament line recycling program as Florida does, the national amount of fishing line debris could be significantly lessened. For example, if the national average was the amount found in all states, the total fishing line debris found during the 2010 ICC could

have been over 3 million pieces. If Florida's 2010 average was the average of all states, the amount of fishing line debris found during the 2010 ICC could have been less than 80,000 pieces (97% less). This is crucial because fishing line is the number one cause of wildlife entanglement and entanglement can lead to, among other things, injury, loss of limb, and even death for wildlife (Trash Travels, 2010). Also, boat props and fishing gear can get entangled in fishing line debris, leading to costly repairs or replacement of boat parts and/or fishing gear (Marine Debris, 2010). Reducing fishing line debris is in the best interest of wildlife, marine ecosystems, and coastal economies.

4. Does the implementation of the cigarette butt litter prevention program by Keep America Beautiful lessen the amount of cigarette butts found during the ICC? Cigarette butt litter did not decrease from 2000 to 2010, and in fact increased even with a decrease in the number of smokers. Most states saw big increases in butts per smoker between 2000 and 2010, with some states, such as RI and CT, increasing more than 80%. The only states that saw a reduction (other than a small reduction in AK) were AL, MS, and LA, three states that were highly impacted by the 2010 bp oil spill. Because of the oil spill AL, MS, and LA had major beach cleanups in the summer of 2010 which could have lessened the number of cigarette butts found during the 2010 ICC. The overall increase in cigarette butt litter from 2000 to 2010 could be a result of a better understanding of the impacts that

cigarette butts have on the environment, leading to a push to clean up as many butts as possible, potentially leading to higher numbers recorded for the 2010 ICC. Keep America Beautiful reports up to a 55% decrease in road side and sidewalk cigarette butt litter in communities that implement their program (Keep America Beautiful, Key Findings, 2010), which supports the theory that more cigarette butts found during the 2010 ICC could be a result of a stronger push to pick up as many as possible. The increase could also be correlated to an increase in volunteers, but volunteer numbers were not available for 2000 and so a comparison between the years could not be made.

CHAPTER 8: FURTHER RESEARCH

The results of this study were not what were expected for any of the variables tested. Each litter prevention technique analyzed, as well as coastal population density, did impact marine debris amounts and types but not to the degree that there were significant statistical differences. This could be because there are many other factors that can influence marine debris types and amounts aside from, and in addition to, the litter prevention techniques. Further research is needed to truly understand what most impacts marine debris, with the goal of reducing the amounts and types of debris in order to reduce the impacts the debris has on the marine environment. The ocean plays a huge role in the economy, recreation, and public health, and anything that threatens the health and safety of the ocean should be understood and prevented, which is why more research is needed.

Possible future research could include a myriad of topics and variables. First, in regards to population and coastline variable, perhaps researching the level of urbanization and the area of impermeable surfaces along the coastline could determine if there is a correlation between runoff and marine debris. Analyzing land-use, land-cover data in total (not just urbanization) in ArcGIS with marine debris amounts may also shed some light on difference in the ICC data. In relation to urbanization, a few regions, such as Manhattan (New York Department of Transportation, 2010), treat storm

water runoff, whereas most municipalities cannot handle storm water and simply let the rain wash directly into coastal waters, taking with it any pollutants, including marine debris. Perhaps there is a correlation between the types and amounts of marine debris and storm water treatment.

Second, in relation to bottle bill status, Delaware repealed there bottle bill in 2010 and stopped bottle redemption on December 1st, 2010 (Container Recycling Institute, 2010). Research on the marine debris in Delaware from before and after the repeal could help illuminate if there is a possible correlation between bottle bill status and returnable debris amounts, even if the correlation is not a strong one. In addition, according to several studies, bottle bills have had a significant impact on the reduction of roadside litter. However, if many states are picking up roadside litter before it becomes marine debris, then analyzing marine debris amounts will not illustrate any reduction in returnable debris. More research on roadside litter may show a strong correlation between bottle bill status and decreased returnable litter. If that was the case, the implication for saving time & money on road side litter control, & the potentially decreased environmental impacts could be illustrated by the roadside litter analysis and could help to implement future bottle bills.

In addition to further research on roadside litter, perhaps instead of looking at returnable debris, the focus should be on recyclable debris and recycling rates per state. Analyzing the ICC data with respect to all recycling (curbside, drop off, bottle redemption, and others) may help illustrate the

impacts of recycling on lessening marine debris, and could help to support more laws governing mandatory recycling.

Third, a potential research focus could be on public waste receptacle availability and density, and the amounts and types of marine debris. This focus would likely have to be done at the city or county level because local governments are often the facilitators of where, and how many, public waste receptacles are available (Florida Center for Solid and Hazardous Waste Management, 2002). A potential project could look at the amount and density of public ashtrays and the amount of cigarette butt debris, or the amount and density of public recycling bins and the amount of recyclable debris.

Forth, obtaining data on the number of licensed fisherman per state could help to further understand monofilament debris. This project looked at pieces of monofilament debris found per capita because data on fishing licenses were not available for the year 2000, making it impossible to compare 2000 data to 2010 data. However, in the future, with better record keeping, calculating the pieces of monofilament line debris per fisherman may be possible, helping to ascertain whether increased participation in monofilament recycling does in fact lessen the amount of monofilament line debris, a very harmful type of marine debris.

Lastly, in addition to calculating certain debris types per capita, it would be useful to also calculate them per volunteer. Volunteer numbers were not available for the year 2000 from the Ocean Conservancy, but they

are available for the year 2010 and will likely continue to be available for each year in the future. Studying the debris per volunteer could be more illuminating that the debris per capita because with increased volunteers comes increased debris cleanup, which could render per capita data useless. Parallel to that, calculating debris per kilometer of coastline that was cleaned, rather than total coastline length could also be useful. In some states, the entire coastline may have been the focus of a cleanup, but other states may have had only certain areas of the coastline that were cleaned, and calculating debris per kilometer of coastline cleaned could provide additional insight into the data.

CHAPTER 9: LITERATURE CITED

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APPENDIX A: 2000 ICC RAW DATA

Debris (2000)	Alabama	Alaska	Arizona	Arkansas	California	Com. N. Marinas Is.	Connecticut	Delaware	District of Columbia	Florida	Georgia	Guam
PLASTIC												
Food bags/w rappers	6,348	992	351	179	65,735	93	1,116	2,882	223	34,729	282	2,873
Salt bags	174	5	1	1	950	0	4	10	1	465	2	42
Trash bags	1,465	186	122	46	15,119	49	118	499	41	7,386	21	910
Other plastic bags	2,123	424	99	98	12,768	183	234	851	56	10,278	76	883
Beverage bottles	6,094	611	371	223	16,808	47	453	1,840	152	22,702	320	1,204
Bleach, cleaner	507	27	22	17	2,073	2	14	203	23	2,863	54	186
Milk/w ater gallon jugs	1,346	28	33	55	1,776	0	58	262	2	2,510	53	293
Oil, lube bottles	901	51	23	32	1,456	1	13	184	23	2,128	38	194
Other plastic bottles	1,633	177	74	57	6,092	14	68	547	67	7,230	137	731
Buckets	307	21	6	15	1,632	0	10	120	7	1,601	20	111
Caps, lids	5,384	564	201	152	43,219	13	1,134	2,859	56	52,615	370	1,595
Cigarette butts	61,721	5,128	916	313	222,523	621	5,990	5,568	116	172,297	848	6,358
Cigarette lighters	629	51	27	28	3,343	6	42	200	20	4,307	33	264
Cups, utensils	1,974	268	122	74	15,502	36	405	1,213	72	14,706	149	1,316
Diapers	235	35	24	53	1,129	2	23	62	8	1,099	4	228
Fishing line	786	385	187	63	4,732	25	79	607	6	5,379	27	345
Fishing lures, floats	534	144	73	48	1,609	6	27	521	10	3,252	19	159
Fishing nets	282	71	1	2	802	5	11	86	2	1,193	14	130
Hard hats	36	235	2	0	215	2	0	9	1	141	1	18
Light sticks	194	7	6	1	1,811	5	0	83	0	2,416	18	124
Plastic pieces	8,999	582	43	23	70,566	15	1,762	2,812	73	44,358	347	3,135
Pipe thread protector	90	52	2	1	1,101	0	6	42	1	522	3	72
Rope	1,696	667	35	37	7,903	34	189	648	23	8,527	108	527
Sheeting longer than 2 ft	222	14	2	6	535	0	4	34	3	570	1	76
Sheeting 2 ft or shorter	236	41	0	17	1,280	1	11	113	5	1,072	5	90
Six-pack holders	719	54	65	36	2,657	26	16	166	13	2,444	7	749
Strapping bands	453	150	18	19	3,891	10	38	167	8	2,708	37	275
Straw s	3,153	258	48	62	36,945	35	685	1,399	100	27,507	219	524
Syringes	48	0	2	10	716	0	11	19	20	587	1	43
Tampon applicators	140	16	8	5	1,267	0	12	100	7	886	13	41
Toys	592	28	25	8	3,835	1	101	443	24	3,240	34	221
Vegetable sacks	352	66	24	5	1,815	3	12	43	1	849	4	66
"Write protection" rings	184	26	21	1	1,830	0	35	77	1	1,638	14	85
Other plastic items	3,302	522	39	37	22,889	97	684	1,373	85	14,123	188	1,322
FOAMED PLASTIC												
Buoys	638	78	23	15	1,810	1	65	209	4	3,247	82	204
Cups	3,051	363	165	89	19,228	78	264	990	150	16,894	223	1,411
Egg cartons	223	10	37	5	434	1	0	28	1	671	18	63
Fast food containers	910	174	114	32	5,802	9	56	336	37	5,230	48	559
Meat trays	422	48	17	23	1,733	34	14	272	6	1,385	51	158
Packaging material	1,053	133	44	7	19,629	57	126	443	13	7,386	77	556
Foamed plastic pieces	5,402	421	13	157	88,115	6	775	1,745	42	36,816	1,044	1,970
Plates	401	79	14	38	3,933	72	21	157	14	3,207	30	949
Other foamed plastic items	1,507	172	8	26	13,873	19	131	530	26	7,733	68	902
GLASS												
Beverage bottles	5,415	847	287	180	23,101	86	391	1,741	99	35,880	388	2,612
Food jars	732	34	35	34	1,519	1	10	118	12	2,239	24	258
Other glass bottles/jars	1,180	68	39	32	2,887	48	22	238	21	3,875	26	591
Fluorescent light tubes	106	0	0	0	232	1	1	18	1	445	2	24
Light bulbs	282	1	3	1	715	1	3	86	7	1,097	45	92
Glass pieces	6,895	461	73	119	42,780	218	816	1,746	65	15,791	81	7,175
Other glass items	127	38	3	5	5,025	10	36	145	14	2,150	9	753
RUBBER												
Balloons	788	12	4	27	9,537	0	165	879	17	3,371	82	140
Condoms	182	6	2	5	1,642	0	9	40	10	1,070	10	55
Gloves	560	63	3	19	3,233	3	33	116	6	1,908	10	134
Tires	364	75	9	44	2,029	12	11	126	15	1,391	4	152
Other rubber items	1,155	79	49	21	7,728	26	142	424	24	4,789	48	692
METAL												
Bottle caps	3,685	475	149	66	22,336	55	384	671	11	24,211	143	1,534
Aerosol cans	460	23	20	21	1,136	3	55	113	6	1,852	50	324
Beverage cans	8,721	1,640	849	256	16,592	1,242	674	3,027	214	32,152	455	7,156
Food cans	754	125	75	9	2,236	21	23	148	16	1,979	5	361
Other cans	532	30	15	6	1,312	0	12	95	2	1,268	5	249
Crab/lobster traps	303	0	1	1	411	0	7	10	0	342	11	6
55 gallon drum - rusty	54	12	1	3	620	1	5	25	0	216	0	96
55 gallon drum - new	9	0	0	0	97	0	1	8	0	60	0	27
Metal pieces	2,177	340	11	29	8,773	1	217	417	3	5,616	52	876
Pull tabs	1,399	163	76	36	4,132	42	72	150	3	4,507	47	521
Wire	646	126	12	30	4,122	23	22	154	2	2,144	14	471
Other metal items	1,623	176	44	67	13,732	27	369	385	32	4,560	41	769
PAPER												
Paper bags	1,563	162	45	26	7,820	16	84	396	15	5,441	63	374
Cardboard	1,437	127	35	32	5,855	39	79	280	6	3,632	40	608
Cartons	924	97	52	28	3,704	37	64	267	8	3,078	28	417
Cups	1,370	250	157	23	7,553	43	109	382	8	6,279	50	544
New spapers/magazines	527	66	30	12	6,928	5	34	169	0	3,328	16	352
Paper pieces	6,730	734	158	24	71,958	76	766	1,492	13	25,919	240	1,381
Plates	238	49	52	5	2,931	20	18	100	1	2,009	10	427
Other paper items	2,090	62	122	27	13,996	8	263	350	41	5,279	95	406
WOOD												
Crab/lobster traps	23	0	0	0	275	2	2	17	0	273	7	43
Crates	91	3	3	0	301	0	0	32	0	227	1	36
Pallets	187	29	7	1	1,189	1	17	43	1	509	3	56
Other w ood items	1,492	45	9	13	7,785	2	196	244	2	3,476	37	345
Lumber pieces	4,076	209	51	34	12,826	31	201	1,078	21	11,741	160	470
CLOTH												
Clothing/pieces	1,543	271	236	59	10,943	51	232	640	38	7,594	136	1,016
Totals by zone	**186,906**	**20,262**	**6,145**	**3,411**	**1,061,072**	**3,761**	**20,362**	**47,122**	**2,277**	**772,595**	**7,546**	**63,505**

APPENDIX A (CONT.)

Debris (2000)	Hawaii	Illinois	Indiana	Louisiana	Maine	Maryland	Massachusetts	Michigan	Minnesota	Mississippi	Missouri	Montana
PLASTIC												
Food bags/wrappers	7,985	2,179	894	4,149	4,347	1,466	7,912	3,074	1,479	4,995	1,494	13
Salt bags	47	43	7	115	23	2	53	42	37	71	14	0
Trash bags	2,013	360	73	1,313	486	271	1,097	248	178	1,199	197	13
Other plastic bags	1,922	730	299	1,417	831	426	1,633	698	268	1,554	400	0
Beverage bottles	4,308	686	576	5,036	1,694	785	3,276	834	608	3,617	844	5
Bleach, cleaner	445	80	29	719	298	154	453	52	27	297	66	1
Milk/water gallon jugs	525	73	39	1,674	360	113	303	143	46	683	49	1
Oil, lube bottles	291	47	40	629	421	71	220	37	27	398	103	0
Other plastic bottles	1,558	228	93	1,827	459	288	1,043	314	100	963	191	0
Buckets	278	22	28	352	144	76	353	49	63	183	79	0
Caps, lids	6,541	1,582	788	6,697	2,479	859	6,768	3,629	528	3,796	562	6
Cigarette butts	47,375	12,648	6,748	11,496	9,656	2,089	33,597	31,090	3,858	17,691	1,710	151
Cigarette lighters	945	138	70	612	205	78	426	140	56	456	77	0
Cups, utensils	3,223	661	313	1,827	830	405	2,762	881	218	1,518	233	18
Diapers	424	81	45	242	63	21	146	79	37	128	33	0
Fishing line	3,448	83	24	617	327	161	627	196	96	418	330	11
Fishing lures, floats	1,154	29	22	421	189	141	247	144	25	334	329	16
Fishing nets	996	12	6	149	400	43	567	22	63	134	30	1
Hard hats	24	4	2	63	5	0	38	6	0	22	1	0
Light sticks	704	24	5	1,122	117	11	85	11	28	244	20	0
Plastic pieces	18,273	3,086	1,196	6,440	4,068	1,343	8,721	10,523	1,434	4,866	379	21
Pipe thread protector	464	4	3	316	37	24	105	24	9	62	4	0
Rope	3,067	99	138	2,470	3,171	312	4,160	266	76	883	78	5
Sheeting longer than 2 ft	135	11	8	128	95	22	112	44	16	120	12	0
Sheeting 2 ft or shorter	255	64	17	185	222	41	227	62	36	205	8	0
Six-pack holders	730	153	37	475	81	49	189	100	17	605	72	0
Strapping bands	459	224	111	444	493	114	579	148	56	239	15	0
Straws	2,827	1,690	653	4,784	661	539	3,938	3,325	317	2,552	315	2
Syringes	68	56	10	132	40	44	35	123	4	29	3	0
Tampon applicators	156	38	28	218	118	29	868	223	27	96	17	0
Toys	662	100	112	463	357	176	717	290	61	222	41	0
Vegetable sacks	199	46	8	146	92	28	201	44	20	148	51	0
"Write protection" rings	105	58	41	149	72	39	230	200	20	140	3	0
Other plastic items	5,242	936	509	3,828	1,592	242	3,575	1,728	414	1,693	361	24
FOAMED PLASTIC												
Buoys	567	41	24	320	935	111	643	33	18	290	123	1
Cups	2,765	722	275	2,316	1,548	576	2,405	532	392	2,253	695	2
Egg cartons	154	19	3	245	23	16	50	4	21	83	10	0
Fast food containers	1,746	154	76	931	274	123	570	153	117	627	277	0
Meat trays	993	20	11	498	125	60	105	20	22	232	53	0
Packaging material	1,334	293	80	717	896	179	1,171	256	271	1,053	305	0
Foamed plastic pieces	5,117	1,826	599	4,174	4,322	1,078	5,521	2,342	908	3,803	454	8
Plates	1,282	97	57	675	130	67	310	143	52	535	79	0
Other foamed plastic items	1,780	289	154	785	1,064	143	1,202	336	159	679	383	0
GLASS												
Beverage bottles	6,601	1,561	433	4,007	1,381	943	2,989	399	553	3,672	2,037	50
Food jars	726	77	21	408	118	121	129	41	29	244	169	0
Other glass bottles/jars	993	294	36	844	152	178	286	106	82	475	241	1
Fluorescent light tubes	114	2	18	202	54	17	15	2	1	98	3	0
Light bulbs	89	71	7	367	31	32	157	24	8	419	7	0
Glass pieces	9,834	5,739	692	2,655	3,967	1,240	3,310	3,702	1,034	4,978	494	9
Other glass items	3,544	222	130	121	980	79	279	78	121	320	107	2
RUBBER												
Balloons	726	469	720	355	420	497	1,144	2,435	112	216	59	0
Condoms	231	85	29	174	60	12	133	66	12	202	43	0
Gloves	162	84	43	1,022	696	21	494	62	104	557	88	0
Tires	386	34	9	259	173	123	208	58	42	173	69	3
Other rubber items	2,072	397	117	682	1,851	76	1,055	217	117	417	108	15
METAL												
Bottle caps	7,687	2,059	357	3,348	875	606	2,006	1,018	231	3,054	787	3
Aerosol cans	394	56	21	630	102	120	260	43	38	257	176	35
Beverage cans	6,036	1,352	549	5,863	1,435	1,073	3,831	535	990	3,864	2,058	117
Food cans	735	88	28	236	187	30	147	94	59	202	112	2
Other cans	387	69	29	365	94	12	184	85	41	99	48	0
Crab/lobster traps	145	1	2	43	166	7	388	2	1	41	17	0
55 gallon drum - rusty	80	186	3	75	76	4	92	9	8	38	32	0
55 gallon drum - new	4	1	1	9	2		16	1	4	28	0	0
Metal pieces	1,502	1,032	220	869	907	176	1,149	516	311	790	120	10
Pull tabs	1,775	432	124	725	146	192	357	381	81	874	210	7
Wire	638	127	54	269	230	89	255	200	124	378	86	
Other metal items	1,791	439	117	482	1,931	136	1,154	410	258	624	242	22
PAPER												
Paper bags	1,684	284	155	1,023	230	107	841	531	170	1,243	242	2
Cardboard	1,150	133	82	495	251	98	769	263	243	1,043	200	0
Cartons	803	189	74	567	200	69	647	143	159	650	169	0
Cups	1,729	256	136	1,066	368	149	1,222	315	267	1,088	253	2
Newspapers/magazines	1,088	303	82	364	152	132	826	109	146	489	121	0
Paper pieces	8,610	2,943	789	3,656	1,907	437	5,393	3,265	1,237	5,354	677	51
Plates	1,118	86	48	333	102	18	277	717	35	334	69	1
Other paper items	3,721	545	347	876	599	150	1,265	1,666	229	1,004	269	1
WOOD												
Crab/lobster traps	53	0	13	68	142	10	117	0	0	21	0	0
Crates	51	84	3	76	24	8	112	2	0	30	1	0
Pallets	118	125	9	109	51	12	116	8	22	91	7	0
Other wood items	989	849	121	497	378	41	1,005	286	62	556	51	73
Lumber pieces	1,776	580	95	1,582	1,010	593	2,472	308	135	2,161	155	2
CLOTH												
Clothing/pieces	1,580	452	203	1,157	769	269	1,379	495	317	1,125	271	37
Totals by zone	**203,708**	**51,442**	**20,168**	**107,195**	**65,967**	**20,692**	**133,719**	**81,200**	**19,592**	**97,325**	**20,298**	**744**

APPENDIX A (CONT.)

Debris (2000)	Nebraska	Nevada	New Hampshire	New Jersey	New Mexico	New York	North Carolina	Ohio	Oregon	Pennsylvania	Puerto Rico	Rhode Island
PLASTIC												
Food bags/wrappers	430	103	2,447	9,562	5	16,660	9,463	317	3,934	876	227	3,793
Salt bags	20	3	20	39	0	153	123	1	41	25	5	32
Trash bags	262	12	243	1,401	1	2,955	2,203	31	557	175	167	484
Other plastic bags	212	0	305	2,473	0	5,040	2,335	27	823	282	31	1,155
Beverage bottles	341	50	933	3,626	2	11,105	13,617	162	1,137	375	181	2,249
Bleach, cleaner	18	0	91	270	0	910	1,250	10	154	24	15	337
Milk/water gallon jugs	31	14	75	441	1	1,430	1,222	29	230	82	70	612
Oil, lube bottles	16	0	46	207	0	847	1,006	25	115	28	13	278
Other plastic bottles	120	28	250	1,076	5	2,997	2,614	12	511	67	63	726
Buckets	14	11	104	214	0	708	519	13	108	40	5	57
Caps, lids	304	56	2,128	7,851	7	16,089	5,218	200	2,919	722	458	3,372
Cigarette butts	756	526	13,733	20,430	16	24,350	14,983	741	11,834	2,870	406	8,764
Cigarette lighters	50	22	104	434	1	1,638	575	43	213	67	49	318
Cups, utensils	170	339	645	3,208	0	7,860	2,916	105	660	252	814	1,131
Diapers	34	3	52	183	0	580	378	1	72	20	56	74
Fishing line	75	12	200	736	0	1,874	1,086	17	482	63	11	412
Fishing lures, floats	59	6	65	568	0	943	731	16	167	17	1	194
Fishing nets	5	0	141	160	0	415	94	0	122	3	9	149
Hard hats	0	0	5	13	0	41	23	0	2	0	3	4
Light sticks	1	0	13	205	1	389	159	2	92	8	15	47
Plastic pieces	422	403	3,174	8,397	0	16,768	6,163	289	6,305	1,493	188	4,339
Pipe thread protector	33	0	136	146	0	262	126	0	86	13	5	20
Rope	21	0	2,152	1,402	1	3,370	784	31	3,081	38	113	1,108
Sheeting longer than 2 ft	7	0	26	69	0	306	243	6	90	8	2	78
Sheeting 2 ft or shorter	24	0	76	211	0	540	224	16	165	11	8	83
Six-pack holders	41	156	53	322	4	917	819	3	102	50	127	191
Strapping bands	27	0	286	574	0	992	384	7	437	114	19	304
Straws	117	4	759	7,439	6	11,099	2,018	231	1,054	733	264	1,995
Syringes	3	0	29	135	0	348	90	1	34	69	3	51
Tampon applicators	10	0	52	909	0	1,902	219	65	113	49	6	282
Toys	46	0	184	932	0	1,691	615	21	339	58	32	395
Vegetable sacks	20	0	43	174	0	434	299	0	128	26	4	218
"Write protection" rings	7	0	56	301	0	577	56	12	101	28	2	83
Other plastic items	141	18	1,242	2,670	0	7,085	1,581	49	2,141	383	125	1,580
FOAMED PLASTIC												
Buoys	15	0	197	133	1	1,455	423	2	264	22	2	389
Cups	181	291	680	2,030	3	6,689	5,559	193	675	185	59	1,614
Egg cartons	14	11	17	59	0	170	303	5	25	3	6	35
Fast food containers	54	10	164	519	4	1,829	1,836	46	309	114	40	344
Meat trays	21	3	35	134	0	461	360	5	161	5	33	68
Packaging material	133	2	559	1,581	0	2,241	1,934	58	1,025	71	21	364
Foamed plastic pieces	147	267	2,191	4,481	0	10,887	5,251	92	5,158	261	60	2,654
Plates	35	370	138	405	2	1,190	767	25	103	53	93	92
Other foamed plastic items	103	123	290	621	0	2,441	1,482	24	977	84	11	616
GLASS												
Beverage bottles	513	204	1,350	2,585	1	9,372	12,084	91	1,339	268	337	2,014
Food jars	39	2	68	174	0	711	1,191	2	91	25	14	149
Other glass bottles/jars	52	35	137	270	1	1,670	2,171	9	172	56	82	440
Fluorescent light tubes	0	0	9	21	0	30	30	0	10	4	0	8
Light bulbs	2	11	98	43	0	185	210	0	51	2	10	30
Glass pieces	187	477	2,160	2,174	0	13,945	6,389	55	2,105	654	197	3,278
Other glass items	64	5	77	209	0	3,704	497	9	63	40	11	252
RUBBER												
Balloons	25	0	311	1,924	0	3,676	566	51	284	163	6	290
Condoms	28	0	34	140	0	438	232	9	72	21	5	70
Gloves	28	0	132	409	0	809	307	7	217	15	11	172
Tires	24	2	90	125	0	753	1,233	8	110	20	4	98
Other rubber items	32	0	654	603	0	2,287	821	26	430	107	18	645
METAL												
Bottle caps	351	609	762	1,599	10	7,787	2,798	51	1,165	367	402	1,043
Aerosol cans	14	19	49	158	0	785	999	3	76	28	19	231
Beverage cans	629	371	2,096	3,229	8	8,141	10,135	353	1,424	416	224	3,247
Food cans	39	97	64	104	0	822	1,591	1	108	41	40	178
Other cans	36	0	157	86	0	468	688	2	86	44	11	86
Crab/lobster traps	23	0	273	24	0	119	43	0	21	4	0	163
55 gallon drum - rusty	5	0	40	45	0	225	117	1	22	5	2	19
55 gallon drum - new	2	0	11	9	0	26	18	0	4		0	1
Metal pieces	106	133	595	556	0	3,701	2,250	40	499	841	92	530
Pull tabs	70	66	188	366	0	1,246	1,257	33	176	135	142	301
Wire	31	24	194	243	0	943	688	20	372	45	14	162
Other metal items	101	4	473	618	0	3,098	1,191	40	1,069	220	13	566
PAPER												
Paper bags	114	15	312	948	7	2,280	2,639	22	406	105	51	418
Cardboard	65	71	380	700	0	1,987	1,297	40	630	83	158	414
Cartons	89	72	189	637	0	1,489	1,092	45	209	106	77	297
Cups	118	167	271	1,123	0	2,865	2,657	63	362	104	75	533
Newspapers/magazines	45	13	288	994	1	1,639	1,020	51	871	73	113	156
Paper pieces	421	675	2,344	3,589	0	8,070	6,409	149	4,060	683	267	1,942
Plates	48	63	86	506	0	1,094	695	10	80	80	53	77
Other paper items	151	0	542	579	0	2,790	1,066	21	1,721	282	48	560
WOOD												
Crab/lobster traps	23	0	100	28	0	212	18	0	28	1	1	36
Crates	10	0	27	60	0	108	99	0	17	9	10	39
Pallets	5	7	41	92	0	215	144	1	70	2	15	127
Other wood items	2	18	258	824	0	1,693	513	22	424	47	0	497
Lumber pieces	61	14	614	2,283	0	3,935	1,916	17	816	91	25	1,138
CLOTH												
Clothing/pieces	161	60	584	1,056	0	3,641	1,954	78	838	201	94	644
Totals by zone	**8,254**	**6,077**	**50,197**	**115,874**	**88**	**267,597**	**161,076**	**4,263**	**67,544**	**15,255**	**6,463**	**61,942**

APPENDIX A (CONT.)

Debris (2000)	South Carolina	South Dakota	Texas	U.S. Virgin Islands	Vermont	Virginia	Washington	West Virginia	Wisconsin	Wyoming	Totals
PLASTIC											
Food bags/wrappers	2,264	10	12,380	676	28	5,438	1,845	109	1,077	0	**227,434**
Salt bags	75	0	286	1	0	5	59	0	17	0	**3,014**
Trash bags	504	0	3,647	262	2	439	533	4	134	0	**47,426**
Other plastic bags	666	8	5,300	390	10	2,277	864	23	164	0	**60,636**
Beverage bottles	1,959	15	7,520	531	35	2,890	1,124	37	320	1	**121,304**
Bleach, cleaner	75	0	1,739	60	2	154	247	0	8	1	**13,977**
Milk/water gallon jugs	222	0	1,776	231	3	307	360	2	23	0	**17,586**
Oil, lube bottles	182	0	1,156	75	2	258	199	1	24	0	**11,806**
Other plastic bottles	440	0	3,528	235	2	457	433	4	133	0	**37,592**
Buckets	151	0	723	24	1	134	78	21	11	0	**8,413**
Caps, lids	2,906	3	17,127	821	5	1,661	1,086	66	2,055	0	**207,451**
Cigarette butts	18,862	0	17,967	763	4	3,853	2,049	33	8,705	0	**812,153**
Cigarette lighters	302	6	1,228	53	2	194	126	4	53	0	**17,635**
Cups, utensils	870	0	4,245	1,128	3	999	596	19	221	0	**74,907**
Diapers	93	6	631	111	1	47	79	0	24	0	**6,646**
Fishing line	235	0	2,040	81	6	360	199	41	73	0	**26,962**
Fishing lures, floats	211	0	699	23	4	169	147	3	52	7	**13,535**
Fishing nets	51	0	797	40	0	92	76	2	12	1	**7,191**
Hard hats	15	0	73	1	0	8	4	0	6	0	**1,023**
Light sticks	234	0	1,543	27	0	59	33	0	17	2	**9,883**
Plastic pieces	2,018	0	20,716	933	18	2,446	914	100	3,708	0	**271,859**
Pipe thread protector	30	0	315	7	1	16	15	0	12	0	**4,167**
Rope	261	0	9,763	402	8	602	1,263	4	117	2	**59,642**
Sheeting longer than 2 ft	24	0	363	13	3	73	79	2	6	0	**3,568**
Sheeting 2 ft or shorter	43	0	834	14	17	74	119	3	18	0	**6,673**
Six-pack holders	136	10	1,191	47	2	165	153	4	51	0	**14,004**
Strapping bands	105	0	1,227	34	1	198	624	1	114	0	**16,104**
Straws	1,593	0	5,457	804	10	2,821	425	17	991	0	**130,375**
Syringes	7	0	299	13	0	11	11	0	30	0	**3,135**
Tampon applicators	98	0	330	33	0	78	40	0	46	0	**8,545**
Toys	302	0	1,456	62	16	577	77	5	78	0	**18,639**
Vegetable sacks	50	0	471	11	0	51	126	2	3	0	**6,283**
"Write protection" rings	91	0	435	18	0	18	41	4	22	0	**6,821**
Other plastic items	940	0	5,552	429	3	1,197	585	10	1,075	0	**91,611**
FOAMED PLASTIC											
Buoys	96	0	675	24	1	120	287	0	21	0	**13,609**
Cups	1,237	0	4,641	463	4	2,070	524	15	152	0	**84,652**
Egg cartons	48	0	606	10	2	20	45	1	4	0	**3,503**
Fast food containers	505	18	1,211	224	3	768	414	3	110	0	**26,880**
Meat trays	126	0	706	17	0	69	179	2	1	0	**8,688**
Packaging material	679	0	1,968	88	2	1,018	253	1	252	0	**48,329**
Foamed plastic pieces	3,133	0	8,323	453	9	2,724	832	66	1,313	0	**214,960**
Plates	268	0	1,558	294	1	121	123	2	15	0	**17,997**
Other foamed plastic items	704	0	2,081	191	2	215	156	1	415	0	**42,506**
GLASS											
Beverage bottles	1,880	0	6,716	994	17	2,794	1,201	91	577	4	**140,085**
Food jars	76	5	838	66	3	126	202		16	0	**10,897**
Other glass bottles/jars	143	5	1,129	182	1	218	143	1	66	0	**19,698**
Fluorescent light tubes	9	0	258	1	0	29	25		2	0	**1,792**
Light bulbs	60	0	430	24	0	121	66	1	5	0	**4,894**
Glass pieces	707	0	7,756	616	2	2,396	1,466	126	1,311	0	**159,875**
Other glass items	255	0	835	118		212	38	5	39	0	**20,731**
RUBBER											
Balloons	175	0	1,362	30	0	749	82		159	0	**32,028**
Condoms	48	0	451	85	1	43	43	1	45	0	**5,844**
Gloves	182	0	1,920	155	1	112	86	2	83	0	**14,069**
Tires	114	0	434	39	0	248	75	1	25	0	**9,172**
Other rubber items	342	0	1,807	176	0	670	48	2	118	2	**31,089**
METAL											
Bottle caps	1,114	0	4,717	926	15	584	493	33	427	2	**101,006**
Aerosol cans	97	0	589	47	0	173	114	4	40	0	**9,640**
Beverage cans	2,231	10	7,768	335	6	3,235	1,387	107	401	33	**146,467**
Food cans	111	0	600	83	2	757	72	3	64	0	**12,449**
Other cans	26	0	429	72	1	103	47	6	140	80	**7,507**
Crab/lobster traps	21	0	87	8	0	11	15	0	2	0	**2,719**
55 gallon drum - rusty	10	0	257	38	0	17	17	0	25	0	**2,481**
55 gallon drum - new	0	0	36	14	0	4	2	0	0	0	**395**
Metal pieces	255	0	1,388	208	15	448	135	29	259	3	**38,197**
Pull tabs	250	0	905	57	0	174	135	10	122	0	**22,085**
Wire	163	0	767	81	1	176	88	8	102	0	**14,338**
Other metal items	201	0	1,039	197	2	507	183	21	244	4	**39,222**
PAPER											
Paper bags	403	0	1,746	151	2	281	562	6	132	0	**33,117**
Cardboard	275	0	980	166	6	182	415	8	92	0	**24,846**
Cartons	139	0	931	125	3	147	185	8	79	0	**18,293**
Cups	472	0	1,353	240	15	380	369	3	169	0	**34,958**
Newspapers/magazines	148	0	742	188	0	92	293	2	67	0	**22,075**
Paper pieces	1,757	0	4,767	525	25	984	1,238	36	1,242	0	**182,993**
Plates	143	0	707	169	0	329	199		26	0	**13,363**
Other paper items	338	0	1,210	150	1	429	1,454	3	377	0	**45,133**
WOOD											
Crab/lobster traps	27	0	187	6	0	10	9	0	0	0	**1,752**
Crates	24	0	201	8	0	60	30	0	3	0	**1,790**
Pallets	29	0	486	32	0	132	77	0	9	0	**4,195**
Other wood items	646	0	1,839	77	0	1,277	393	2	71	0	**27,157**
Lumber pieces	1,296	0	4,893	317	1	1,079	346	4	141	0	**60,754**
CLOTH											
Clothing/pieces	408	0	2,810	387	13	545	289	17	346	0	**44,939**
Totals by zone	**57,386**	**96**	**219,953**	**17,210**	**346**	**55,087**	**29,444**	**1,152**	**28,709**	**142**	**4,191,169**

APPENDIX B: 2010 ICC RAW DATA

Debris (2010)	Alabama	Alaska	Arizona	Arkansas	California	Colorado	Connecticut	Delaware	District of Columbia	Florida	Georgia	Hawaii
Paper Bags	2210	700	46	48	29269	88	1884	320	180	10374		2526
Plastic Bags	5119	839	253	315	65736	543	5383	1224	1170	34469		6647
Balloons	339	57	25	6	6211	12	892	270	48	3674		1247
Plastic Beverage Bottles	6081	1186	464	467	25773	526	5281	1437	1346	34895		3342
Glass Beverage Bottles	4120	1211	340	447	27292	385	3977	1042	1543	26197		5280
Beverage Cans	6610	1721	1013	754	22041	492	3202	1170	833	25316		2928
Caps, Lids	4659	1309	303	314	64517	395	8497	2917	1042	64485		19039
Clothing, Shoes	943	321	116	114	10563	145	862	299	99	6672		8173
Cups, Plates, Forks, Knives, Spoons	3544	478	269	206	39254	180	3801	816	797	25182		5797
Food Wrappers/Containers	5503	1576	336	256	124637	616	13877	2447	1485	53049		12366
Pull tabs	1010	127	44	164	8701	60	1056	10	119	7224		2231
6 Pack Holders	434	42	15	35	1517	19	144	39	45	1867		299
Shot Gun Shells/Wadding	153	274	19	31	4013	27	321	275	33	561		297
Straws/Stirrers	2016	281	114	130	32124	175	4763	1130	310	24707		2902
Toys	832	143	43	19	10442	21	1313	336	116	4898		932
Bait Containers/Packaging	412	54	19	109	1850	101	354	140	36	2492		541
Bleach/Cleaner Bottles	159	81	1	31	809	3	94	38	2	854		480
Buoys/Floats	317	230	3	22	1053	22	349	63	18	1464		859
Crab/Lobster/Fish Traps	98	14	0	2	666	0	34	20	2	427		1093
Crates	68	14	0	3	274	0	28	10	2	363		179
Fishing Line	637	229	173	647	5804	89	814	244	139	11387		5947
Fishing Lures/Light Sticks	202	75	88	73	1296	40	170	76	3	1940		570
Fishing Nets	106	75	2	20	620	3	40	48	8	815		1976
Light bulbs/tubes	112	19	0	3	513	10	84	20	5	607		338
Oil/Lube Bottles	180	76	3	62	953	47	84	49	13	1090		318
Pallets	36	29	1	5	437	5	15	31	5	279		93
Plastic Sheeting/Tarps	458	108	8	16	6422	11	343	158	35	3841		560
Rope	630	546	32	41	5145	128	730	212	26	5845		3177
Strapping Bands	417	113	8	33	4219	69	230	152	20	2070		709
Cigarettes/Cig Filters	15877	4079	1259	419	335320	1185	30057	11093	997	214248		67070
Cigarette Lighters	419	42	30	274	2921	14	322	216	42	2552		645
Cigar Tips	891	99	0	17	16072	19	1547	689	163	15192		1550
Tobacco Packaging/Wrappers	1141	167	20	83	8568	86	956	261	114	5780		1764
Appliances (Refridgerators, washers, etc)	60	3	1	13	361	5	19	7	0	117		58
Batteries	157	37	4	38	1381	5	68	22	17	754		568
Building Materials	1791	812	60	33	12233	23	561	620	119	5805		1271
Cars/Car Parts	232	101	20	16	1773	107	138	77	24	1267		669
55-Gallon Drums	8	5	0	1	88	1	9	2	0	57		19
Tires	223	27	6	41	1323	20	64	35	8	759		246
Condoms	108	20	0	0	1832	1	441	44	18	1500		130
Diapers	148	52	11	78	787	16	100	34	15	533		215
Syringes	74	3	0	0	616	1	35	7	2	511		81
Tampons/Tampon Applicators	51	13	4	24	721	8	493	171	24	667		122
Totals	68585	17388	5153	5410	886147	5703	93432	28271	11023	606786	0	165254

APPENDIX B (CONT.)

Debris (2010)	Idaho	Illinois	Indiana	Iowa	Kansas	Louisiana	Maine	Maryland	Massachusetts	Michigan	Minnesota	Mississippi
Paper Bags	10	2281	577	3	590	1482	933	563	1858	1138	218	2241
Plastic Bags	18	5796	856	122	787	1538	2824	3587	6363	3186	365	3729
Balloons	0	967	472	0	2	46	298	353	1522	2225	31	235
Plastic Beverage Bottles	44	5908	935	75	421	1899	1858	7104	7009	1952	324	3328
Glass Beverage Bottles	2	3030	658	55	75	1226	1102	1884	3117	1323	279	5414
Beverage Cans	77	3341	1084	71	596	1367	1408	2440	3943	2096	580	3233
Caps, Lids	17	13419	2632	0	157	2300	1996	5625	100119	7587	462	3706
Clothing, Shoes	17	1128	250	11	19	203	491	1161	1308	813	125	639
Cups, Plates, Forks, Knives,	59	4213	1116	0	322	901	1135	2640	3950	2544	365	1769
Food Wrappers/Containers	90	10189	2700	14	536	2832	3785	4974	11923	8924	2096	4185
Pull tabs	10	1072	146	0	10	194	276	882	648	596	134	567
6 Pack Holders	0	285	22	23	1	73	82	114	178	136	9	183
Shot Gun Shells/Wadding	18	199	150	0	0	8	251	292	1016	590	5	139
Straws/Stirrers	23	4890	1359	0	156	1155	734	3325	3913	4405	229	877
Toys	0	1173	352	87	103	118	327	1409	1699	1063	59	236
Bait Containers/Packaging	0	217	17	102	0	23	246	414	535	172	44	137
Bleach/Cleaner Bottles	0	51	34	0	5	24	256	86	276	25	5	71
Buoys/Floats	0	45	16	0	0	9	1119	96	504	51	10	119
Crab/Lobster/Fish Traps	0	29	0	0	0	3	529	51	531	8	0	63
Crates	0	33	5	1	0	1	96	22	111	13	0	29
Fishing Line	4	137	36	60	2	118	168	760	1032	179	16	261
Fishing Lures/Light Sticks	12	79	28	80	0	51	46	141	249	114	7	62
Fishing Nets	0	35	4	9	2	17	142	48	288	26	2	69
Light bulbs/tubes	0	41	3	4	0	42	28	23	75	23	2	62
Oil/Lube Bottles	0	47	19	6	4	20	156	81	143	32	2	122
Pallets	0	314	4	0	2	6	38	14	68	10	1	29
Plastic Sheeting/Tarps	0	715	60	1	91	75	349	197	561	672	51	259
Rope	0	281	64	3	4	95	3114	322	4638	593	12	309
Strapping Bands	0	438	71	0	26	40	1159	118	909	266	21	200
Cigarettes/Cig Filters	160	33433	13956	1	10	4295	22730	13615	30365	26735	5901	11332
Cigarette Lighters	3	419	52	0	3	166	77	274	543	312	25	130
Cigar Tips	3	2959	687	0	2	269	246	1248	965	4035	32	891
Tobacco Packaging/Wrappe	2	829	162	6	12	533	459	522	791	383	143	784
Appliances (Refridgerators,	0	14	2	0	0	3	87	9	40	4	1	29
Batteries	0	163	12	0	0	66	30	31	94	77	8	83
Building Materials	0	554	99	5	28	286	782	509	819	689	149	1044
Cars/Car Parts	0	150	3	0	5	138	84	118	142	62	312	407
55-Gallon Drums	0	3	3	1	0	1	5	11	23	9	1	5
Tires	0	50	42	17	3	23	63	203	79	29	15	557
Condoms	1	376	19	0	1	63	54	91	250	61	11	110
Diapers	2	109	53	0	0	25	21	42	90	77	13	53
Syringes	0	41	8	0	0	4	37	80	140	22	7	14
Tampons/Tampon Applicator	1	347	117	0	2	13	179	53	631	146	5	34
Totals	573	99800	28885	757	3977	21751	49800	55532	193458	73403	12077	47746

APPENDIX B (CONT.)

Debris (2010)	Missouri	Nebraska	Nevada	New Hampshire	New Jersey	New Mexico	New York	North Carolina	Ohio	Oklahoma	Oregon	Pennsylvania
Paper Bags	0	795	0	606	617	7	16135	1675	1851	5	62	3219
Plastic Bags	32	1163	18	1551	4541	32	22505	5610	6394	36	302	5629
Balloons	0	31	8	224	1124	0	5625	375	165	0	99	683
Plastic Beverage Bottles	127	745	47	996	6167	62	21260	7968	4927	65	293	8192
Glass Beverage Bottles	112	567	44	1118	1674	19	16848	5171	2595	264	348	4056
Beverage Cans	88	1151	112	1862	2896	159	16955	6716	4132	369	333	6268
Caps, Lids	0	466	164	1725	16256	21	40787	4821	3196	50	1248	5023
Clothing, Shoes	12	96	13	431	801	4	5124	1143	626	13	130	909
Cups, Plates, Forks, Knives,	15	405	24	1156	6340	5	19246	2692	3304	73	175	3421
Food Wrappers/Containers	13	1369	106	3738	9773	30	34808	7571	8645	80	904	10951
Pull tabs	0	72	50	248	200	0	4192	746	279	227	122	783
6 Pack Holders	0	14	3	21	98	19	1907	146	78	1	24	185
Shot Gun Shells/Wadding	0	165	14	219	427	0	2988	112	228	0	59	208
Straws/Stirrers	0	112	42	788	13203	15	21837	1909	1547	28	248	2847
Toys	2	35	2	394	1149	4	4479	1000	604	1	64	728
Bait Containers/Packaging	1	415	4	103	258	0	1742	688	338	2	66	425
Bleach/Cleaner Bottles	0	1	0	15	114	5	821	124	87	2	13	109
Buoys/Floats	0	79	0	207	172	0	1096	251	40	0	45	80
Crab/Lobster/Fish Traps	0	0	0	800	66	0	438	52	1	0	11	11
Crates	0	0	0	29	94	0	179	25	19	0	3	9
Fishing Line	0	284	6	739	528	7	3109	3021	165	20	667	372
Fishing Lures/Light Sticks	0	47	5	59	344	12	915	224	69	5	100	244
Fishing Nets	0	3	6	113	84	0	413	64	19	0	23	40
Light bulbs/tubes	0	2	0	13	89	0	638	94	60	0	29	68
Oil/Lube Bottles	0	11	0	32	115	1	1349	187	117	0	7	157
Pallets	0	3	0	21	71	0	175	13	8	2	5	40
Plastic Sheeting/Tarps	0	37	2	362	83	2	1934	231	373	0	29	349
Rope	0	11	3	4226	487	4	8928	446	98	0	445	155
Strapping Bands	0	7	0	669	534	0	907	194	157	0	83	209
Cigarettes/Cig Filters	0	1133	166	23059	24518	100	65386	27388	4505	500	2939	31590
Cigarette Lighters	1	25	2	68	719	0	2148	237	244	0	60	401
Cigar Tips	0	35	0	173	4429	0	4915	724	5724	0	121	1969
Tobacco Packaging/Wrapper	0	138	2	192	1137	16	3432	902	424	20	83	1148
Appliances (Refridgerators,	1	4	0	2	6	2	111	367	20	3	2	110
Batteries	2	8	4	9	82	0	1037	98	43	9	9	144
Building Materials	60	93	4	451	304	0	7013	986	694	0	43	3176
Cars/Car Parts	8	21	0	140	38	1	792	263	529	2	12	580
55-Gallon Drums	1	6	0	0	14	2	55	35	7	0	3	62
Tires	9	38	0	86	88	3	559	2179	270	3	12	903
Condoms	0	6	0	23	126	0	700	122	101	0	19	87
Diapers	0	14	0	21	54	25	933	163	56	1	12	147
Syringes	0	1	0	6	96	0	224	25	19	0	17	72
Tampons/Tampon Applicator	0	5	7	31	1167	0	3009	86	270	2	29	162
Totals	484	9613	858	46726	101083	557	347654	86844	53028	1783	9298	95921

APPENDIX B (CONT.)

Debris (2010)	Rhode Island	South Carolina	South Dakota	Texas	Utah	Vermont	Virginia	Washington	West Virginia	Wisconsin	Wyoming	Totals
Paper Bags	1597	1057	20	4194	198		2177	712	0	330	54	95160
Plastic Bags	8094	4092	15	21236	773		15616	1778	6	1441	80	252694
Balloons	1486	470	0	1557	124		874	170	0	181	2	32224
Plastic Beverage Bottles	7186	12664	55	17937	668		18100	1935	1	817	66	222670
Glass Beverage Bottles	4778	4966	45	8339	377		9377	1010	0	1162	21	153577
Beverage Cans	5739	6157	70	12782	877		11015	1646	8	1472	51	167727
Caps, Lids	12755	5831	30	33650	318		7340	1691	0	4010	34	355770
Clothing, Shoes	1835	1043	18	4424	138		1873	543	4	241	24	54398
Cups, Plates, Forks, Knives,	6169	3405	26	10745	261		10808	944	6	833	41	170700
Food Wrappers/Containers	12885	8070	22	12159	1239		15559	3735	1	1900	105	402595
Pull tabs	902	745	0	2418	81		457	138	14	95	4	37333
6 Pack Holders	347	171	14	990	30		449	76	0	28	0	10430
Shot Gun Shells/Wadding	877	850	0	1002	216		336	252	0	192	0	16847
Straws/Stirrers	6226	2681	10	6668	223		3258	941	0	750	23	153520
Toys	1435	799	13	2399	79		1742	250	1	292	17	41420
Bait Containers/Packaging	787	538	23	824	135		1012	228	0	177	0	15876
Bleach/Cleaner Bottles	389	156	0	852	4		224	56	0	1824	0	8299
Buoys/Floats	503	294	0	540	53		193	185	0	27	0	10161
Crab/Lobster/Fish Traps	469	64	0	289	0		73	10	0	1	0	5859
Crates	94	29	0	174	0		44	5	0	7	0	1966
Fishing Line	2077	775	80	2658	450		1003	399	2	65	1	45317
Fishing Lures/Light Sticks	473	222	24	1074	37		291	69	0	65	0	9713
Fishing Nets	296	88	0	663	0		131	75	0	5	0	6385
Light bulbs/tubes	61	68	0	433	1		171	17	0	14	0	3786
Oil/Lube Bottles	171	218	0	713	3		565	37	1	20	0	7338
Pallets	148	34	0	120	2		19	30	1	11	0	2130
Plastic Sheeting/Tarps	583	263	0	2220	36		615	219	1	103	0	22500
Rope	2978	509	20	7782	35		640	2402	0	83	2	55263
Strapping Bands	614	278	0	919	2		791	644	0	56	0	17368
Cigarettes/Cig Filters	43623	58787	50	18818	1183		19107	6352	16	7908	163	1181589
Cigarette Lighters	548	411	0	1218	26		429	102	0	111	1	16257
Cigar Tips	1223	1535	0	2885	4		1545	189	0	108	0	73155
Tobacco Packaging/Wrapper	1105	845	5	1164	61		1664	268	2	341	34	36592
Appliances (Refridgerators,	19	12	0	72	1		58	4	0	0	2	1633
Batteries	104	89	2	278	2		102	43	0	25	0	5716
Building Materials	1344	1118	7	1819	34		1542	710	1	169	55	48138
Cars/Car Parts	201	218	5	595	13		484	35	0	23	2	9826
55-Gallon Drums	16	9	2	46	0		24	0	0	6	0	545
Tires	112	240	5	236	19		1605	91	0	20	5	10365
Condoms	137	114	0	452	17		148	39	0	49	2	7282
Diapers	200	106	4	495	16		275	52	1	35	0	5195
Syringes	161	14	0	197	0		23	36	0	110	0	2704
Tampons/Tampon Applicator	853	76	0	328	5		112	55	0	31	0	10589
Totals	131600	120111	565	188364	7741	0	131871	28173	66	25138	789	3788612